An Ecological Survey of the Gulf of Naples Area: Conducted During September 15 to October 15, 1976, For the Region of Campania

By

Carl H. Oppenheimer

Dorothy A. Oppenheimer

Roberto Blundo

Submitted To

Assessore Dr. Silvio Pavia
Region of Campania
Naples, Italy 80100

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I. Introduction

The coastal environments of the world are one of man's greatest assets. Coastal zones are not only esthetically pleasing as used for various forms of recreation, such as swimming, diving, and boating, they also can be evaluated in economic terms, e.g. transportation, resources of water and minerals, industry, fisheries, etc. Throughout the history of mankind, the oceans have played a vital role as a main means of transportation and communication. Most of the large cities of the world originating as centers of trade were established on or near the coastline or on rivers where they were easily accessible by ships.

However, modern-day man is placing a much heavier burden on the coastlines of the world. At the same time that man is beginning to realize the finite value of his coastal environment, both esthetically and economically, he is altering the coastal environment at an ever-increasing rate, often without looking ahead to future consequences.

The purpose of this study is to apply methodologies developed for an environmental evaluation of the Texas coastal environment to the Bay of Naples area. In the short time allowed, we have tried to evaluate the present status of the Bay of Naples through a search of the literature and personal observations and to show man's use of the environment, as well as its economic value. We have also tried to show where new information will be required to complete a thorough evaluation of the environment in future years.

The following plot illustrates the associated effects of man's activities on his environment generally applied to the region of the Gulf of Naples and surrounding land. The symbol x indicates an impact of the action to a specific aspect of the ecology of the area. The following chapters address some of the most pertinent effects as related to man's activities.

Finally we have developed an intermediate concept of ocean disposal for sewage and industrial wastes. This intermediate concept is only viable if the continual development of secondary sewage and industrial waste treatment is followed. However it is possible that future research may show that the ocean outfall concept may provide adequate disposal criteria for many years to come.

II. Description of the Area

Coastal environments throughout the world are complicated, balanced systems influenced by time, hydrography, biology, chemistry, meteorology, coastal morphology and man's activities. Each portion of the coast is further influenced by the surrounding major geographic features.

The Bay of Naples, while representing a finite portion of the Italian coast (Figure 1), must also be considered as a part of the Mediterranean/Black Sea system and the extensive weather system of Southern Europe. Throughout the years volcanic activity has had a major impact on the area.

The Naples area with its very mild climate has attracted people from all over the world. The Mediterranean coast of Italy is well-known for its beauty. Archeological findings and remains

MAN'S ACTIONS \ ECOLOGICAL EFFECTS	LAND					WATER															AIR			
	Land drainage and leeching	Fertilizers	River runoff	Street runoff	Photosynthesis	Photosynthesis	BOD	Oxygen	Nutrients	Salinity	Toxic chemicals	Pesticides	Floating debris	Color	Suspended solids	Temperature	pH	Odors	Hydrocarbons	Coliforms	Sulfur	N-Ox	Organics	Hydrocarbons
Urban development																								
Sewage			X		X	X	X	X	X		X	X	X	X	X		X	X	X	X	X			
Streets	X			X																				
Autos	X			X														X	X		X	X		X
Industry																								
Chemical waste	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X						
Water use			X							X														
Water release	X		X		X					X				X		X								
Resource exploitation																								
Sea water	X		X		X					X														
Fresh water			X							X														
Fishing							X						X	X	X			X						
Transportation																								
Ship											X	X	X	X				X	X	X	X		X	X
Land	X			X	X																X	X	X	X
Recreation																								
Swimming																				X				
Fishing and boating																			X	X				X
Esthetics	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

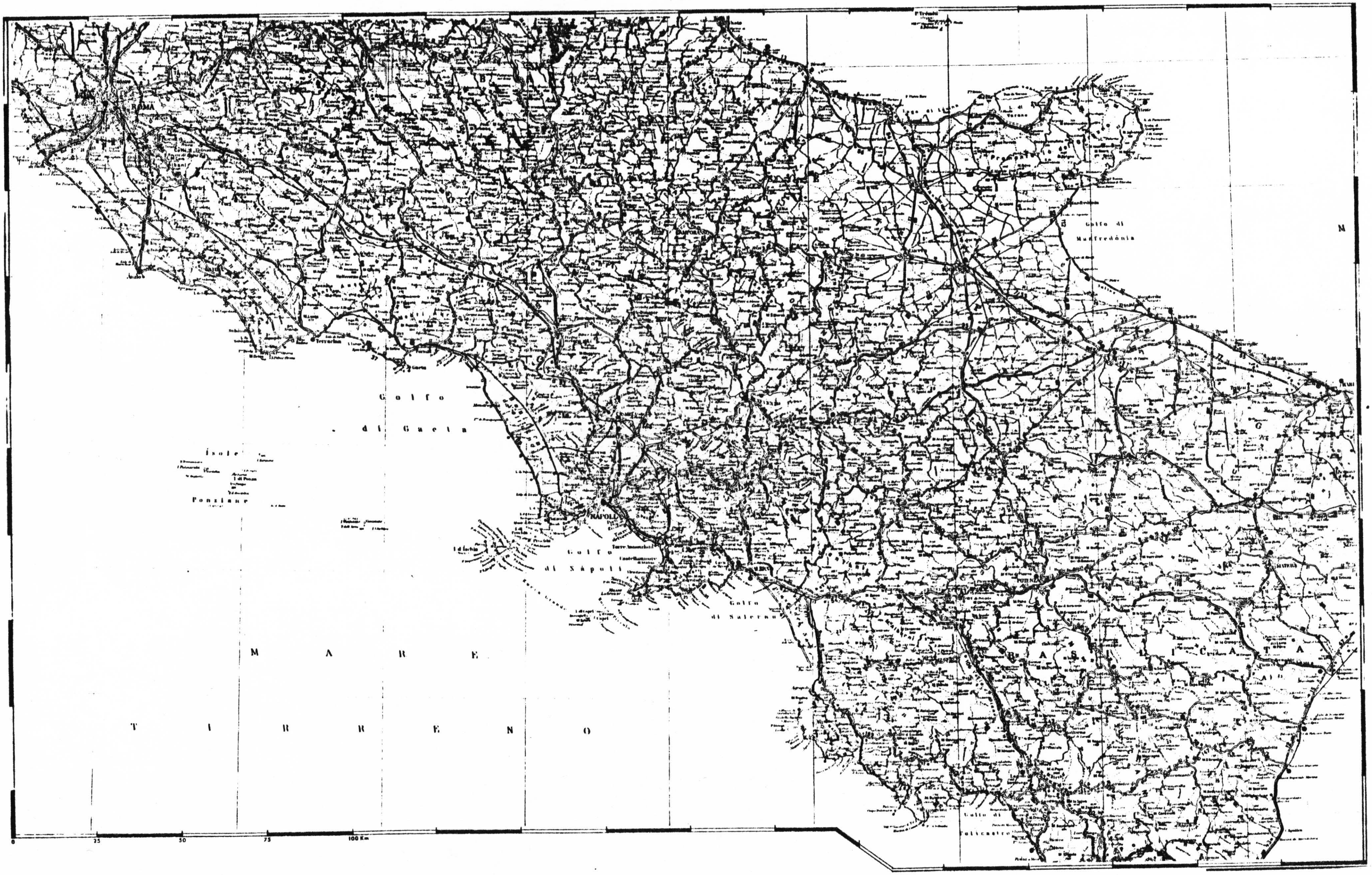


Figure 1. A map of the Italian coast adjacent to Naples.

are common and provide an historical insight into the growth of the area and mankind, as well as attracting tourists and scientists from all over the globe. The land is fertile and productive due to the long growing season, mild winters, and abundant rainfall.

The coastline is picturesque; its warm, clear waters are inviting to the swimmer and diver. Boating is both a commercial business and widely enjoyed for recreation. Tourism is a major industry of the area; it has many inducements to offer for short and lengthy tourism visits.

Naples originated as the town of Parthenope, approximately 700 BC. This tranquil bay, enclosed by the Islands of Capri and Ischia, provided a haven for seamen and a safe port for Central Italy. At this early date, the original plan of the city was laid out much as we see it today. The many caves in the limestone cliffs provided shelter for the early inhabitants. Hovering in the distance, the great mountain of Vesuvius, with its fertile lava slopes, must have seemed to reign supreme to these early settlers even though it violently affected the area at times.

Naples has been a major new- and old-world port almost since its settlement. Because of its port facility, it was one of the first Italian towns to become industrialized. This industry is significant for the city has grown around many of the major industrial sections.

The following ecological description of the Region Campania, Italy, and specifically the Bay of Naples, has been organized to show how the regional approach to an environmental assessment of a coastal area may be used to provide data and information for management purposes. During the short period of the study, from September 15 - October 15, 1976, it was not possible to obtain all pertinent information for the area. However, sufficient information was obtained to permit an evaluation of the regional approach and to show that information can be derived or planned in the future that may allow responsible maintenance of the environment.

A. Population

In 1961, the population of Campania was 4,738,000 (Table 1) and Mendia, et al. (1976) estimates a total population of almost 7 million by 2015. Figure 2 shows the population of the Region Campania relative to runoff into the Bay of Naples. Table 2 shows estimated population for the years 1986 and 2016 for the study area of the Cassa della Mezzogiorno. Figure 3 shows the growth of principle sites of Italy, including Naples from 1871 to 1971. This has been one of the most populated towns in Italy since the days of man's first written accounts (Fig. 3). It was one of the first major sea ports for the Mediterranean and was the first area to establish modern industry.

B. Physiographic Features

Physiographically, the coastal area is one of alternating alluvial plains, carbonate-bluff hills, and the mountain of Vesuvius, with its slopes of lava and volcanic ash. Considerable volcanic activity has been present both in the surrounding upland areas and in subterranean zones near the coast, as shown in Figure 4.

Table 1. The population of Campania for 1961 and extrapolated to 2015. (Mendia et. al. 1976)

TABELLA 16
Totale Campania

Anno	N° Abitanti		
	Totale	Gravitanti con scarichi sul Golfo di Napoli	% sul Golfo di Napoli
1961	4.738.000	2.204.361	46,5
2015	6.999.750	3.270.780	46,7
Incremento %	47,7	48,3	

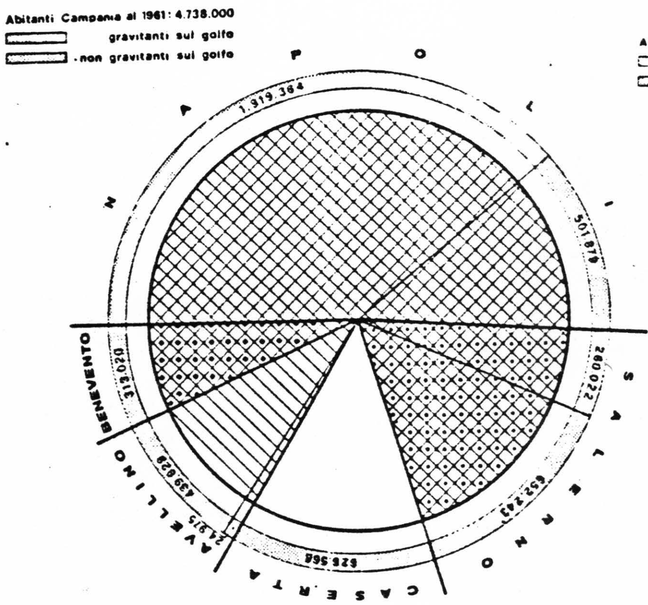


Fig. 2.

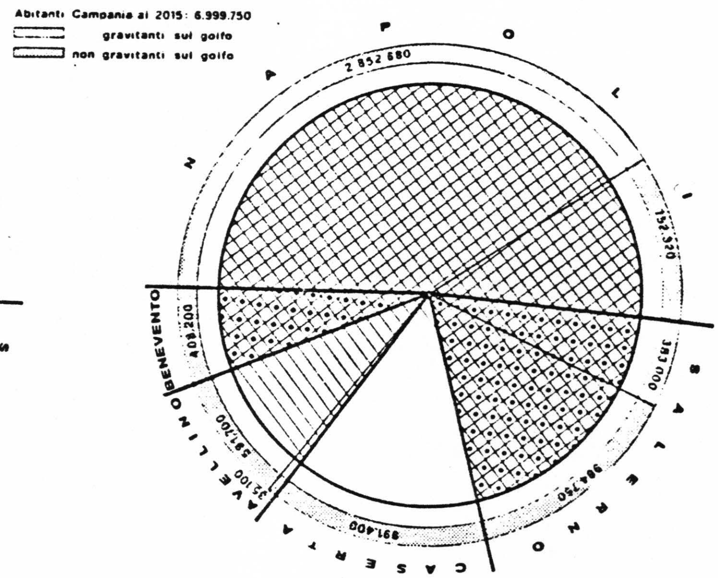


Fig. 3.

Figure 2. Distribution of population in Campania for 1961 and 2015. (Mendia et. al. 1976)

Table 2. Estimated population for Naples region for 1986 and 2016. (Cassa della Mezzogiorno)

AREA DI INTERVENTO SUDDIVISA PER COMPRENSORI

COMPRENSORIO N°	COMPRENSORIO DENOMINAZIONE	N° comuni serviti	PREVISIONE PRIMA FASE AL 1986 Abitanti equivalenti N°	PREVISIONE PRIMA FASE AL 1986 Portata media reflua m^3/s	PREVISIONE PRIMA FASE AL 1986 % $\frac{Qri}{\Sigma Q}$ (1)	PREVISIONE FASE FINALE AL 2016 Abitanti equivalenti N°	PREVISIONE FASE FINALE AL 2016 Portata media reflua m^3/s	PREVISIONE FASE FINALE AL 2016 % $\frac{Qri}{\Sigma Q}$ (1)
1	NAPOLI OVEST	5(*)	1'488'870	4.182	24	1'837'450	7,004	33
2	NAPOLI EST	11(*)	1'961'015	5,376	60	2'218'220	6,869	48
3	ISCHIA E PROCIDA	7	143'660	0,258	8	190'590	0,420	6
4	ALVEO CAMALDOLI	3	195'203	0,433	61	356'401	0,903	62
5	FOCE SARNO	12	905'850	2,222	53	1'127'262	3,121	45
6	C.SORRENTINA-CAPRI	8	218'140	0,423	16	284'230	0,668	14
7	COSTIERA AMALFITANA	14	159'525	0,363	39	210'395	0,559	36
8	SALERNO	11	700'081	1,799	51	1'240'000	3,282	53
9	MEDIO SARNO	17	750'565	1.762	54	1'191'780	3,168	53
10	ALTO SARNO	8	350'575	0,538	72	682'620	1,072	70
11	NOLA	31	435'865	0,947	60	925'065	2,034	65
12	ACERRA-POMIGLIANO	14	828'000	1,823	67	1'062'000	2,788	59
13	NAPOLI NORD	9(*)	841'000	2,005	57	1'555'630	4,665	64
14	CASERTA	15	803'110	1,868	61	1'216'870	3,360	61
15	FOCE REGI LAGNI	28	632'855	1,345	25	1'090'060	2,797	36
	TOTALI	191 (**)	10'414'314	25,346	50	15'188'573	42,710	49

(*) Comprendono solo una parte del Comune di Napoli

(**) La somma è corrispondente al numero di Comuni effettivamente serviti

(1) $\frac{Qri}{\Sigma Q} = \frac{\text{Portata reflua industriale}}{\text{Portata media reflua compressiva}}$

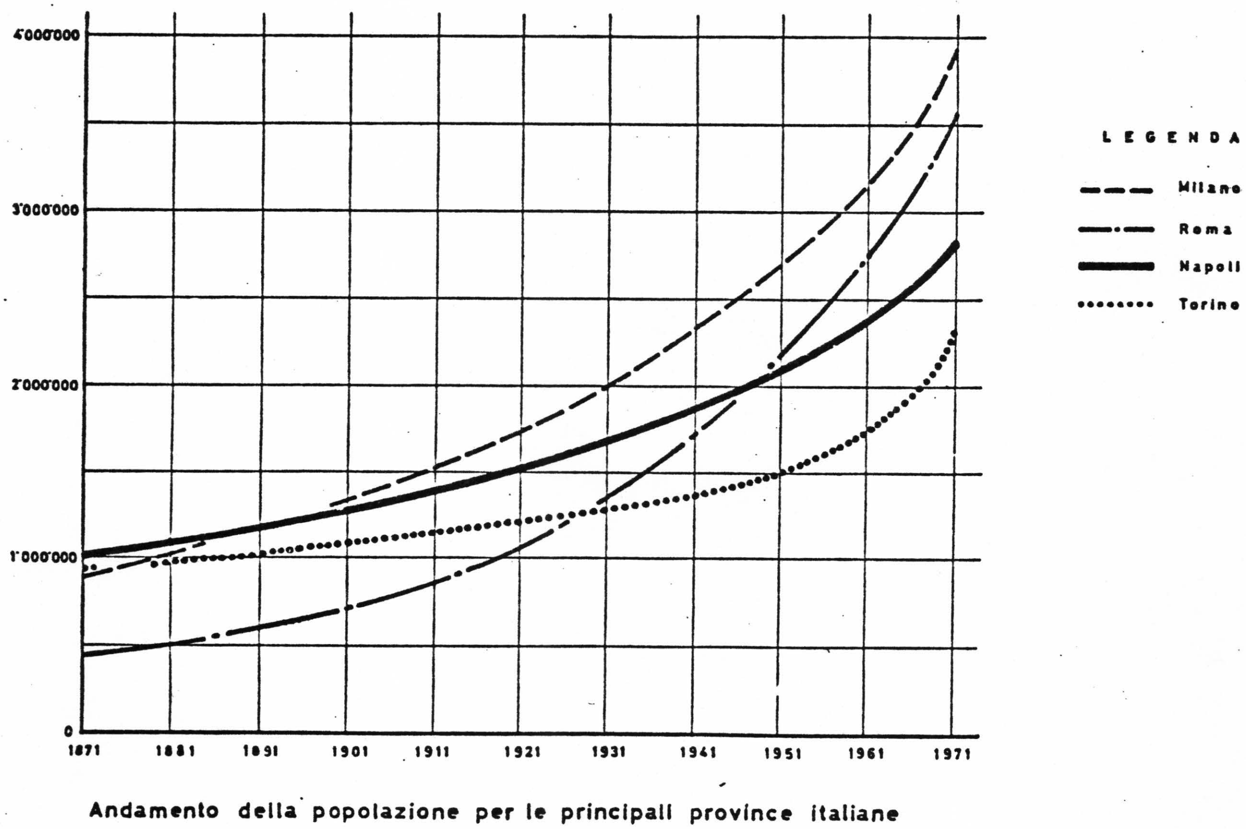


Figure 3. A comparison of the growth of principle regions of Italy since 1871. (Eurostaff Report, vol. II)

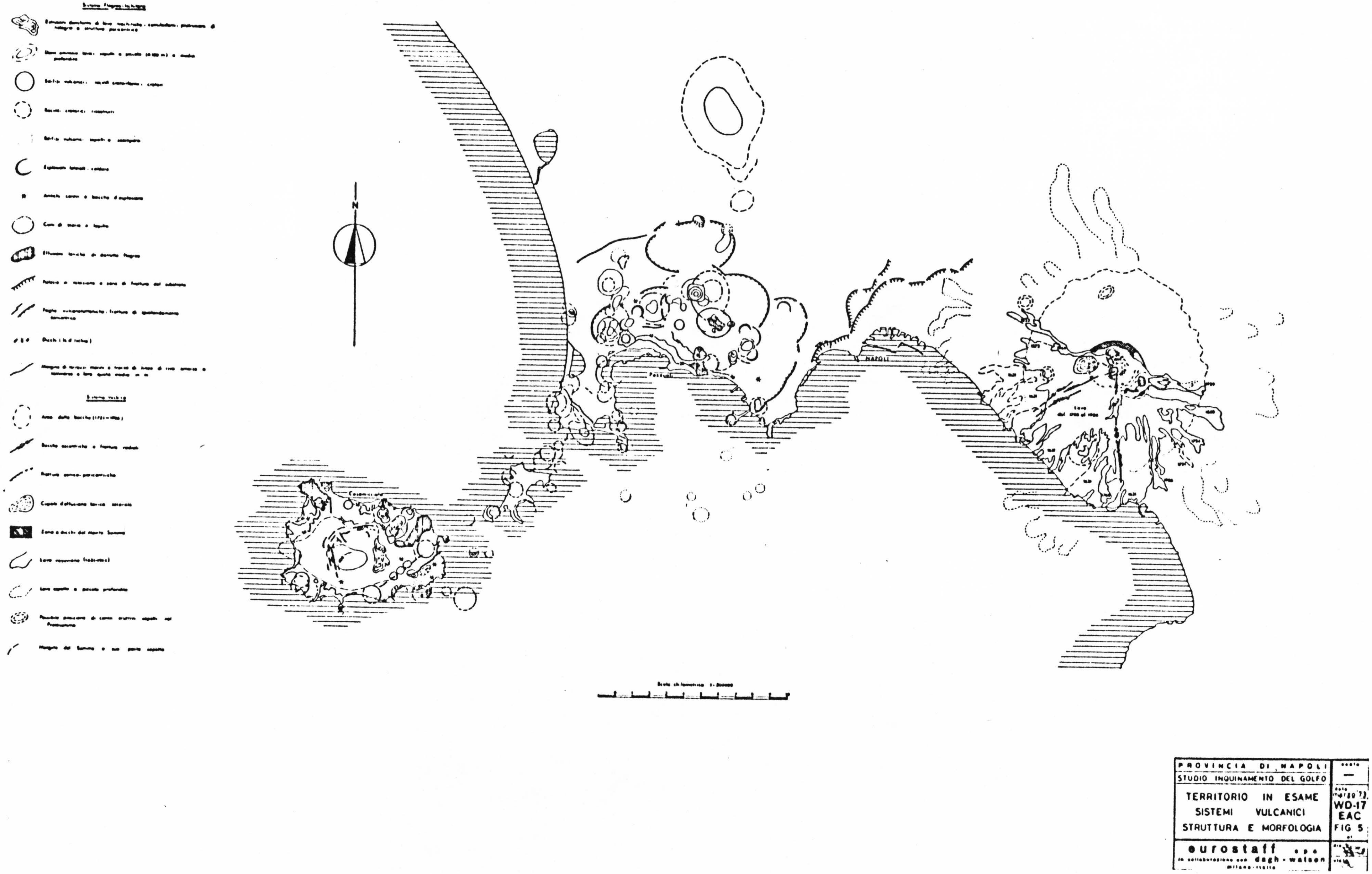


Figure 4. Volcanic structures in the Naples area. (Eurostaff Report, vol. I)

The temperature is mild with adequate rainfall, as shown by typical precipitation and rainfall records in Figures 5-6 and Table 3. Wind velocities and direction are shown in Figures 7-8 and Table 4.

At Capri, the higher winds, found in the winter, come from the north to the east. The data for Naples indicate coastal influence and a seasonal change in the wind direction. The predominant winter winds at Capri may be correlated with the surface currents in the Bay of Naples, as shown in Figure 9, for January of 1973. In the Spring of 1966, the current direction at the surface is shown to be northwest, see Figure 10. The currents at different depths indicated by numbers are shown by the arrow lines representing velocity. The surface current drift is shown by the solid lines between dots, representing observation time of a surface drogue. The depth is given in meters. The general current circulation for the coast of Italy is presented in Figure 11. It is obvious that the Bay of Naples is influenced both by the offshore currents and the local wind structure. In general, the waters in the Bay of Naples are in continuous motion and are constantly being replenished through the Straits of Capri and Ischia.

Upwelling occurs at certain times, as indicated in Figure 12.

The bottom contours, shown in the hydrographic chart (Figures 13-14) which shows the two submarine canyon-type structures, allow a tongue of deeper water to move toward the coast. These data are also supported by more recent data collected by the Zoological Station. The hydrographic data from the Bay of Naples by Hapgood in 1957-58 indicate a surface warming trend in the spring with a

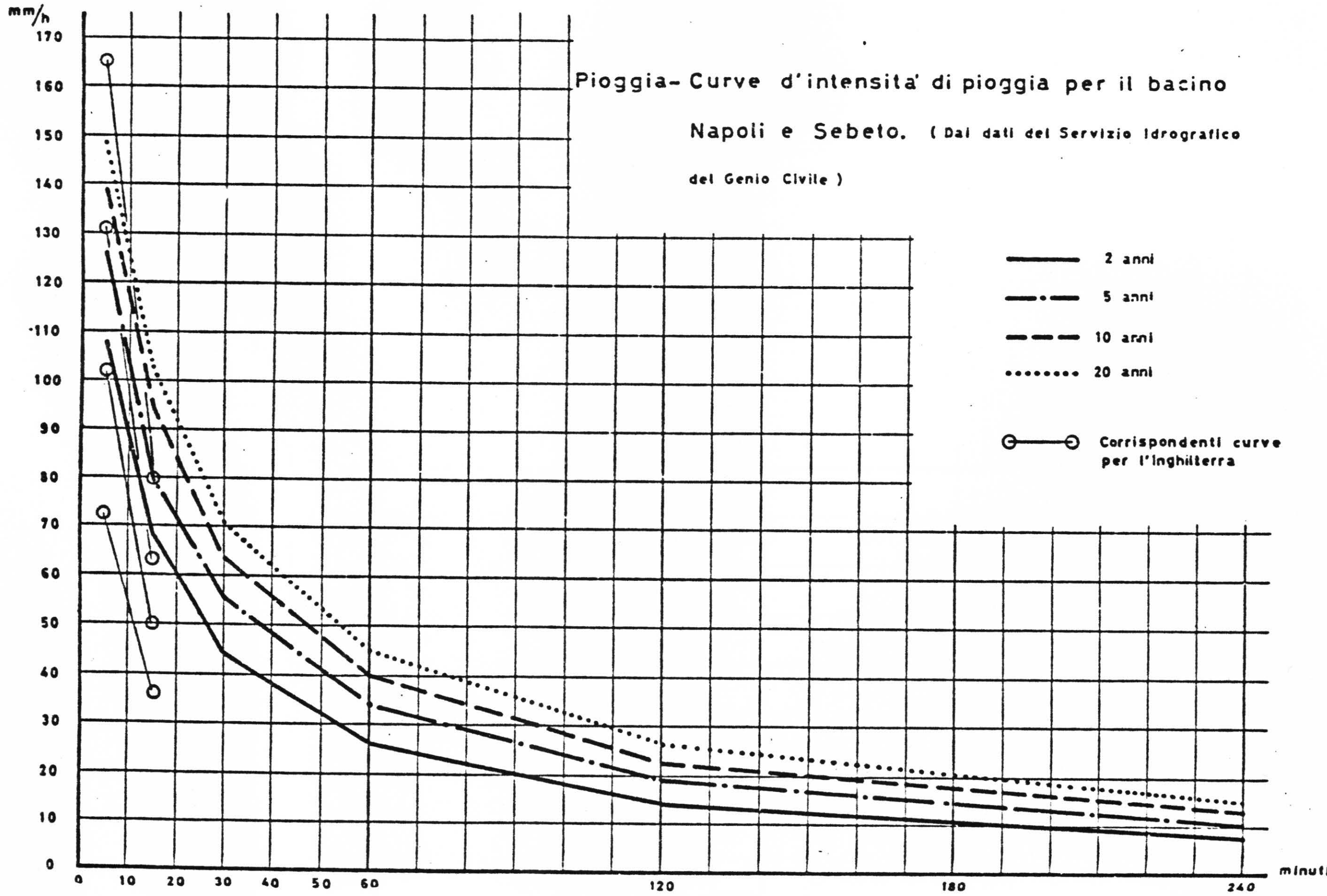
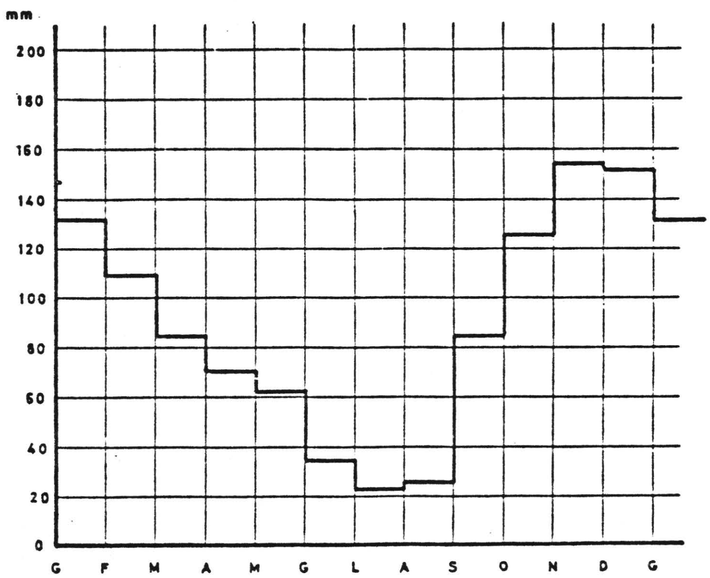


Figure 5. Rainfall intensity curves for two to twenty year averages. (Eurostaff Report, vol. II)



Pioggia - Andamento delle precipitazioni medie mensili, osservate su di 27 stazioni nell'ambito del Napoletano, per un periodo massimo di 47 anni.

Figure 6. Monthly rainfall averages for 47 year period. (Eurostaff Report, vol. II)

Table 3. Monthly precipitation for Naples area.
(Hydrological tables)

Segue TAV. 33 — Temperature e precipitazioni mensili

NAPOLI - *Servizio Idrografico*

MESI	Temperature in C° estreme max.	estreme min.	medie max.	medie min.	medie mens.	Precipitazioni Quantità mm totale	Quantità mm max.	F g.
Dicembre	19,2	5,6	15,0	9,6	12,3	70,2	40,4	5
Gennaio	16,6	5,0	13,4	8,6	11,0	227,2	94,4	12
Febbraio	16,8	— 2,0	12,5	6,7	9,6	190,0	41,8	13
Marzo	19,0	1,1	14,6	8,3	11,5	65,4	25,6	9
Aprile	24,5	6,5	16,5	10,5	13,5	58,8	19,2	8
Maggio	34,0	10,8	25,2	15,0	20,1	—	—	—
Giugno	33,4	17,0	26,1	20,2	23,2	25,4	23,4	2
Luglio	35,0	13,8	29,4	17,9	23,7	33,8	29,6	3
Agosto	34,0	15,4	29,8	18,1	24,0	58,8	27,4	6
Settembre	33,0	15,0	27,5	20,5	24,0	143,2	....	7
Ottobre	27,2	10,5	21,8	15,2	18,5	54,2	20,4	4
Novembre	21,0	0,0	16,3	11,1	13,7	32,8	29,0	3
ANNO	35,0	— 2,0	20,7	13,5	17,1	959,8	....	72

CAPRI SEMAFORO - *Aeronautica*

MESI	Temperature in C° estreme max.	estreme min.	medie max.	medie min.	medie mens.	Precipitazioni Quantità mm totale	Quantità mm max.	F g.
Dicembre	18,4	6,6	14,6	9,7	12,2	39,8	18,8	4
Gennaio	15,1	5,0	12,6	7,9	10,3	165,0	53,4	11
Febbraio	15,4	0,8	11,3	5,8	8,6	153,6	22,8	14
Marzo	18,4	1,2	13,3	6,6	10,0	41,8	7,6	10
Aprile	21,4	3,9	15,0	8,3	11,7	24,8	7,6	6
Maggio	29,8	10,3	23,5	14,4	19,0	0,6	0,4	—
Giugno	32,2	15,2	26,5	17,7	22,1	4,2	3,2	1
Luglio	35,2	16,6	28,8	20,3	24,6	18,6	14,0	3
Agosto	33,6	15,2	29,2	20,6	24,9	51,0	29,2	6
Settembre	30,2	15,2	26,9	19,2	23,1	18,6	9,0	5
Ottobre	28,2	9,6	21,8	15,2	18,5	48,6	28,8	5
Novembre	19,8	2,2	16,8	10,6	13,7	23,2	7,2	4
ANNO	35,2	0,8	20,0	13,0	16,6	589,8	53,4	69

NAPOLI CAPODICHINO - *Aeroporto*

MESI	Temperature in C° estreme max.	estreme min.	medie max.	medie min.	medie mens.	Precipitazioni Quantità mm totale	Quantità mm max.	F g.
Dicembre	17,4	0,5	14,2	6,6	10,4	30,8	11,0	5
Gennaio	15,4	0,0	12,7	5,1	8,9	216,8	73,8	12
Febbraio	16,6	— 3,0	11,7	3,6	7,7	170,6	34,4	13
Marzo	18,4	— 2,8	13,7	4,5	9,1	70,8	20,8	10
Aprile	24,4	2,6	16,1	6,0	11,1	57,4	10,4	10
Maggio	33,2	5,0	24,6	11,8	18,2	—	—	—
Giugno	33,4	12,6	28,0	16,1	22,1	29,4	12,4	3
Luglio	35,2	13,8	29,4	18,1	23,8	8,0	6,4	1
Agosto	34,0	15,4	29,8	18,3	24,1	156,6	92,6	5
Settembre	32,6	12,6	27,4	16,0	21,7	141,4	71,0	6
Ottobre	28,0	5,4	20,6	9,3	15,0	55,0	25,0	5
Novembre	20,2	— 3,5	16,7	6,7	11,7	37,2	27,0	3
ANNO	35,2	— 3,5	20,4	10,2	15,3	974,0	92,6	73

ISCHIA - *Porto*

MESI	Temperature in C° estreme max.	estreme min.	medie max.	medie min.	medie mens.	Precipitazioni Quantità mm totale	Quantità mm max.	F g.
Dicembre	17,5	2,5	14,2	6,9	10,6	133,8	87,0	10
Gennaio	16,5	0,5	12,6	5,8	9,2	225,6	73,0	13
Febbraio	16,5	0,0	12,2	4,6	8,4	192,0	45,0	11
Marzo	19,0	0,0	14,2	4,9	9,6	123,6	37,8	8
Aprile	22,0	3,0	16,1	6,7	11,4	22,0	9,0	5
Maggio	32,0	8,5	24,5	12,4	18,5	—	—	—
Giugno	32,0	13,5	28,2	16,5	22,4	11,5	7,0	2
Luglio	34,5	15,0	30,1	18,9	24,5	—	—	—
Agosto	....	....	....	....	....	....	....	....
Settembre	32,0	14,5	28,5	16,5	22,5	21,4	7,2	5
Ottobre	....	....	....	....	....	....	....	....
Novembre	....	....	....	....	....	....	....	....
ANNO	....	....	....	....	....	....	....	....

SALERNO

16,9	6,2	14,5	9,6	12,1	62,4	27,6	8
16,0	5,7	12,9	8,4	10,7	261,2	90,2	12
16,2	0,8	12,5	6,6	9,6	211,8	37,2	17
20,2	2,1	13,9	7,6	10,8	103,2	39,6	11
21,8	5,0	16,4	9,2	12,8	92,0	24,8	10
32,0	10,2	24,9	15,5	20,2	2,2	1,6	1
35,0	15,8	27,7	19,0	23,4	19,6	9,8	3
35,5	18,1	30,2	21,6	25,9	24,8	9,8	4
34,0	15,2	30,3	21,5	25,9	89,4	41,2	5
33,1	14,9	28,1	19,4	23,8	103,2	27,0	6
30,2	11,2	22,9	15,9	19,4	100,2	52,4	5
21,7	1,8	17,1	11,0	14,1	72,8	46,8	4
35,5	0,8	21,0	13,8	17,4	1.142,8	90,2	86

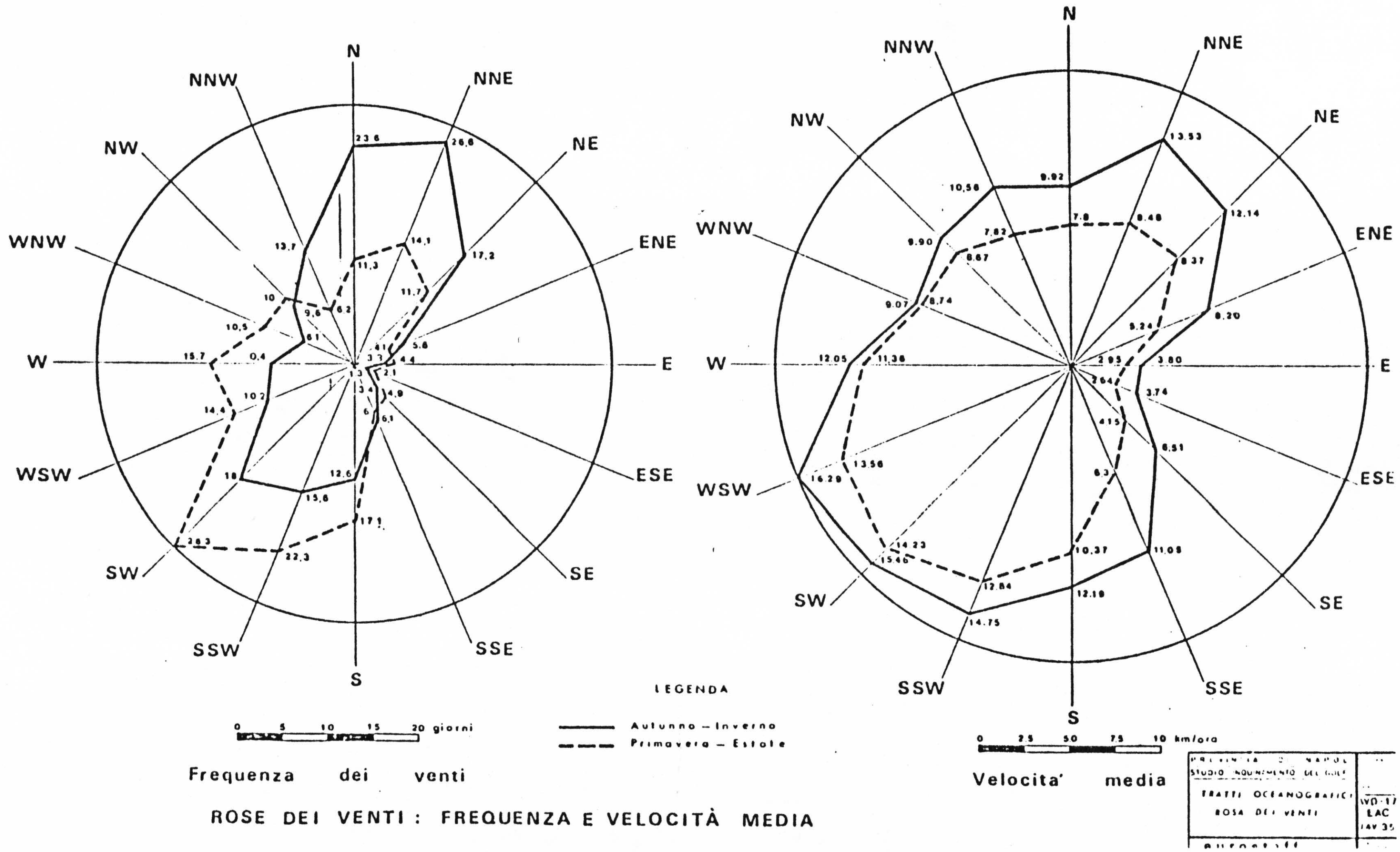


Figure 7. Wind rose- frequency and velocity for the Naples area. (Eurostaff Report, vol. III)

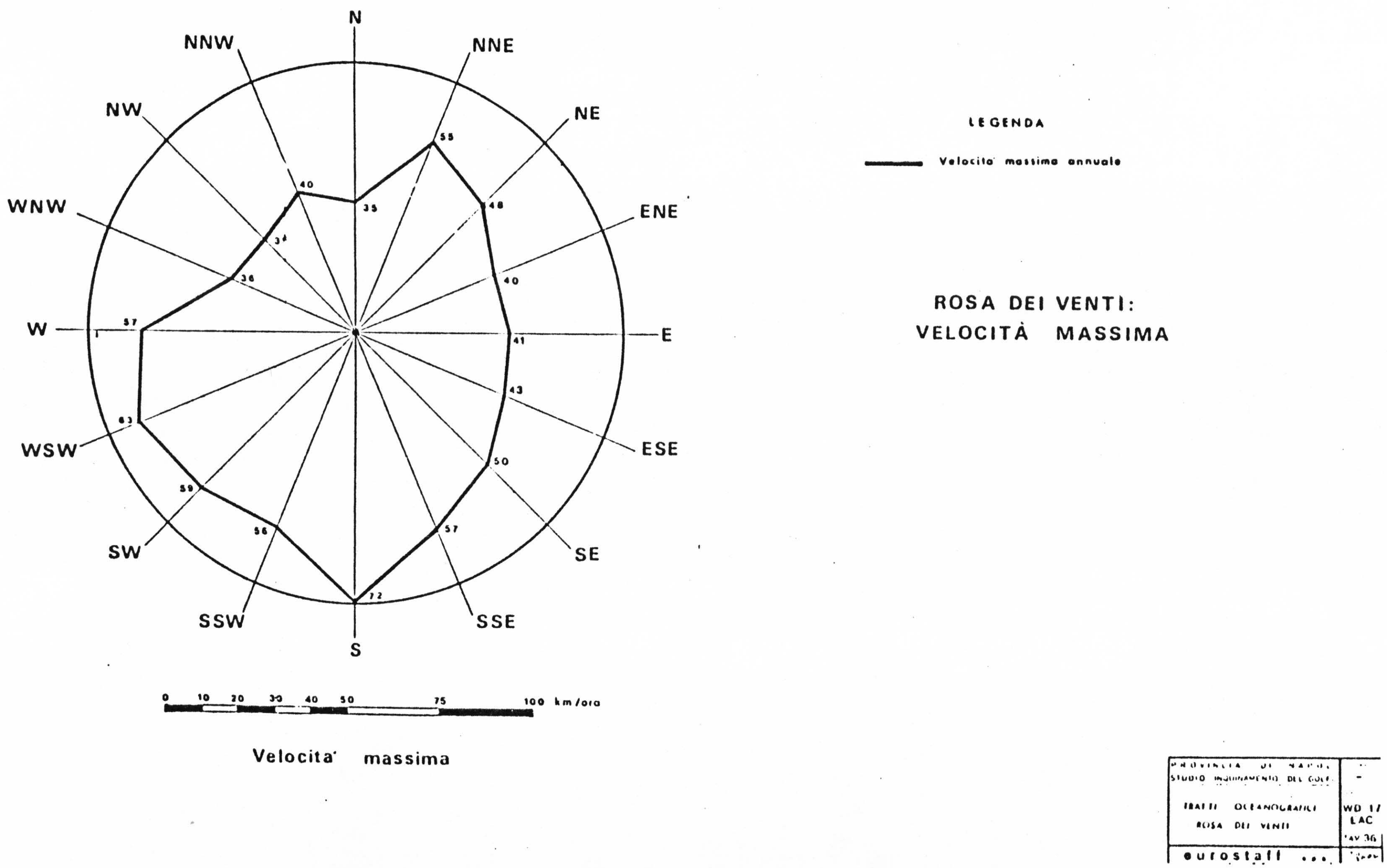


Figure 8. Wind rose of maximum velocity. (Eurostaff Report, vol. III)

Table 4. Frequency and velocity of winds for Capri and Naples. (Hydrological Tables)

Segue TAV. 41 — Vento al suolo — Frequenza e velocità media per direzione di provenienza e velocità massima mensile

MESI	N		NE		E		SE		S		SW		W		NW		Variabile	Calma	MASSIMA MENSILE	
	F	$\overline{V}$	F	$\overline{V}$	F	$\overline{V}$	F	$\overline{V}$	F	$\overline{V}$	F	$\overline{V}$	F	$\overline{V}$	F	$\overline{V}$	F	F	Dir.	Velocità
CAPRI SEMAFORO - *Aeronautica*																				
Dicembre	7	8	10	8	28	6	11	4	4	10	—	—	—	—	2	7	2	29	Var.	41
Gennaio	14	8	12	9	19	6	8	5	6	5	7	8	5	9	6	11	1	15	N	50
Febbraio	9	10	16	11	12	6	5	7	4	5	9	9	8	8	5	13	—	16	NE	63
Marzo	18	9	15	11	12	6	4	6	2	5	1	9	4	9	7	10	1	29	SW	46
Aprile	13	11	7	9	5	6	7	4	3	3	2	6	25	14	12	15	—	16	NW	56
Maggio	20	10	3	10	13	5	3	7	2	6	4	3	5	3	6	7	—	37	SE	34
Giugno	14	10	1	16	14	6	4	3	3	4	2	3	8	7	9	10	—	35	W	46
Luglio	11	9	5	8	7	4	1	3	—	—	6	4	15	7	13	11	—	35	NW	50
Agosto	18	10	2	2	6	4	—	—	1	5	1	2	7	4	3	7	—	55	N	47
Settembre	13	10	3	9	6	6	3	8	4	7	1	4	4	10	9	9	—	47	NW	46
Ottobre	15	7	10	16	10	6	2	4	1	3	5	9	7	12	4	11	1	38	NE	54
Novembre	9	7	10	15	2	4	1	2	1	3	4	13	12	7	11	10	—	40	NW	62
ANNO	161	9	94	11	134	6	49	5	31	6	42	7	100	9	87	11	5	392	NE	63
NAPOLI CAPODICHINO - *Aeroporto*																				
Dicembre	7	3	39	8	2	8	—	—	2	11	2	3	—	—	3	2	—	38	E	44
Gennaio	13	7	27	9	10	9	2	10	6	6	6	6	3	7	5	4	—	21	NE	43
Febbraio	8	5	21	11	9	6	1	4	7	8	9	8	6	9	5	7	—	18	NE	52
Marzo	22	5	28	9	8	12	1	5	7	7	4	5	1	4	6	8	—	16	NE	38
Aprile	8	7	6	13	1	4	1	7	12	7	18	10	20	13	8	4	—	16	W	55
Maggio	5	3	3	6	5	6	1	1	9	5	23	8	4	8	9	6	—	34	SW	32
Giugno	6	4	7	8	1	5	2	4	6	5	25	9	10	9	11	6	—	22	NW	42
Luglio	7	5	9	6	1	7	—	—	5	8	25	8	11	9	11	7	—	24	W	42
Agosto	8	5	6	5	1	3	1	6	11	6	16	8	4	12	17	6	—	29	NW	62
Settembre	8	4	4	4	4	9	1	11	8	7	19	6	5	5	6	3	—	35	NW	68
Ottobre	12	6	20	11	—	—	1	2	5	10	12	10	5	11	16	5	—	22	NE	58
Novembre	6	5	15	8	6	6	—	—	1	14	18	9	5	7	6	5	—	33	W	45
ANNO	110	5	185	9	48	8	11	6	79	7	177	8	74	10	103	6	—	308	NW	68

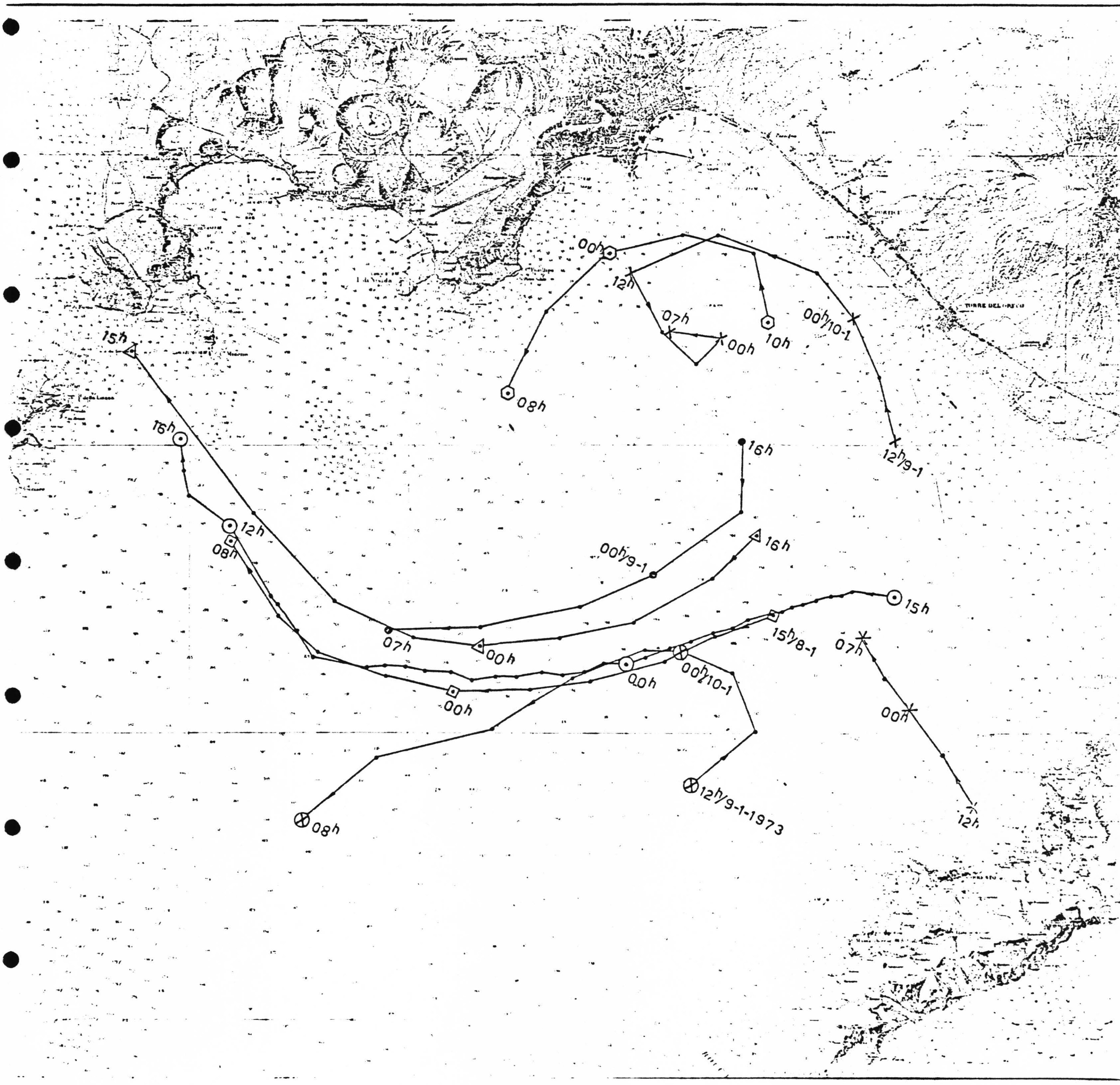


Figure 9. Water movement in the Gulf of Naples for January 1973. (Unpublished data from the University of Naples Institute of Hydrography)

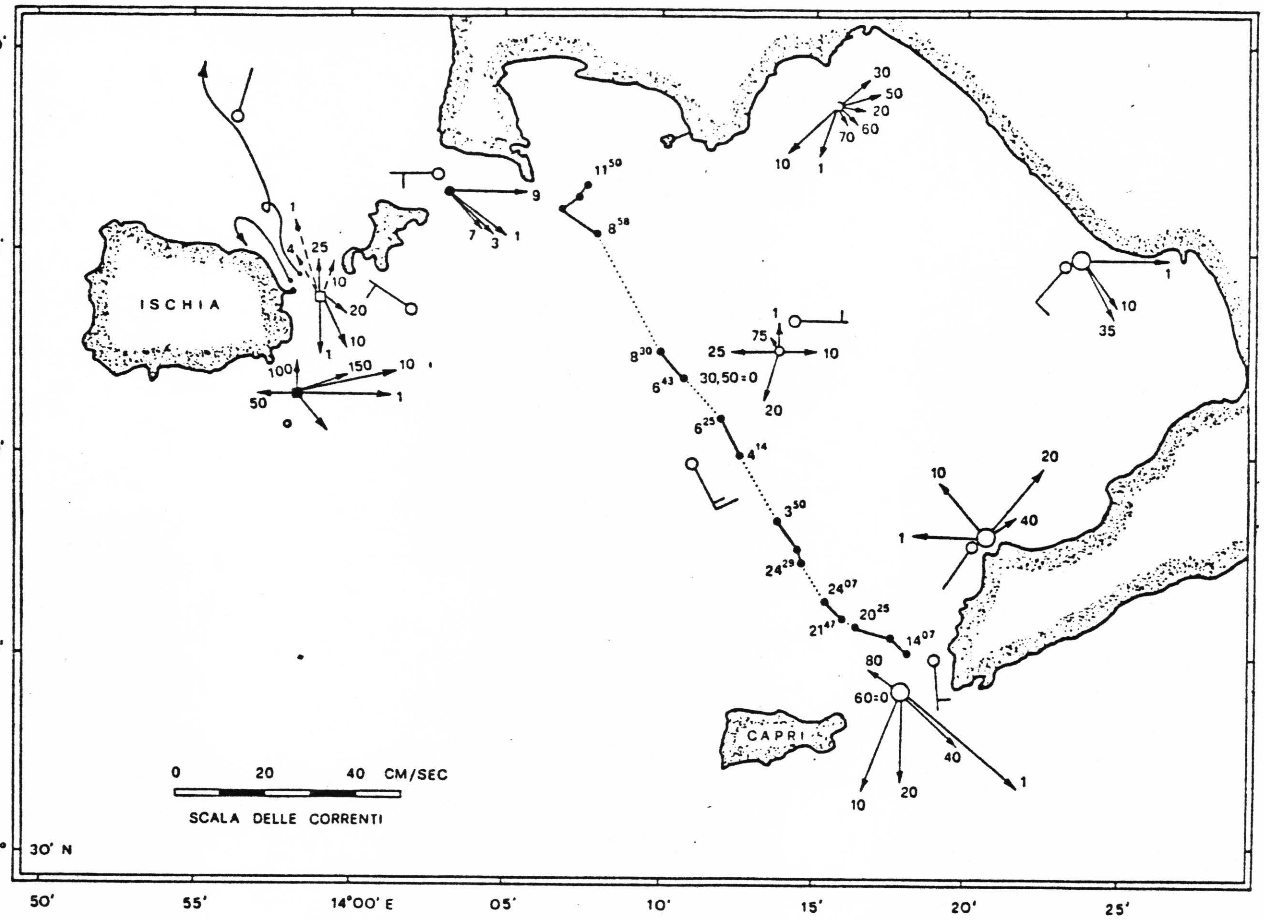


Fig. 10: Quadro dei risultati delle misure dirette delle correnti.

Figure 10. Water movement in the Gulf of Naples. (De Maio and Moretti, 1973)

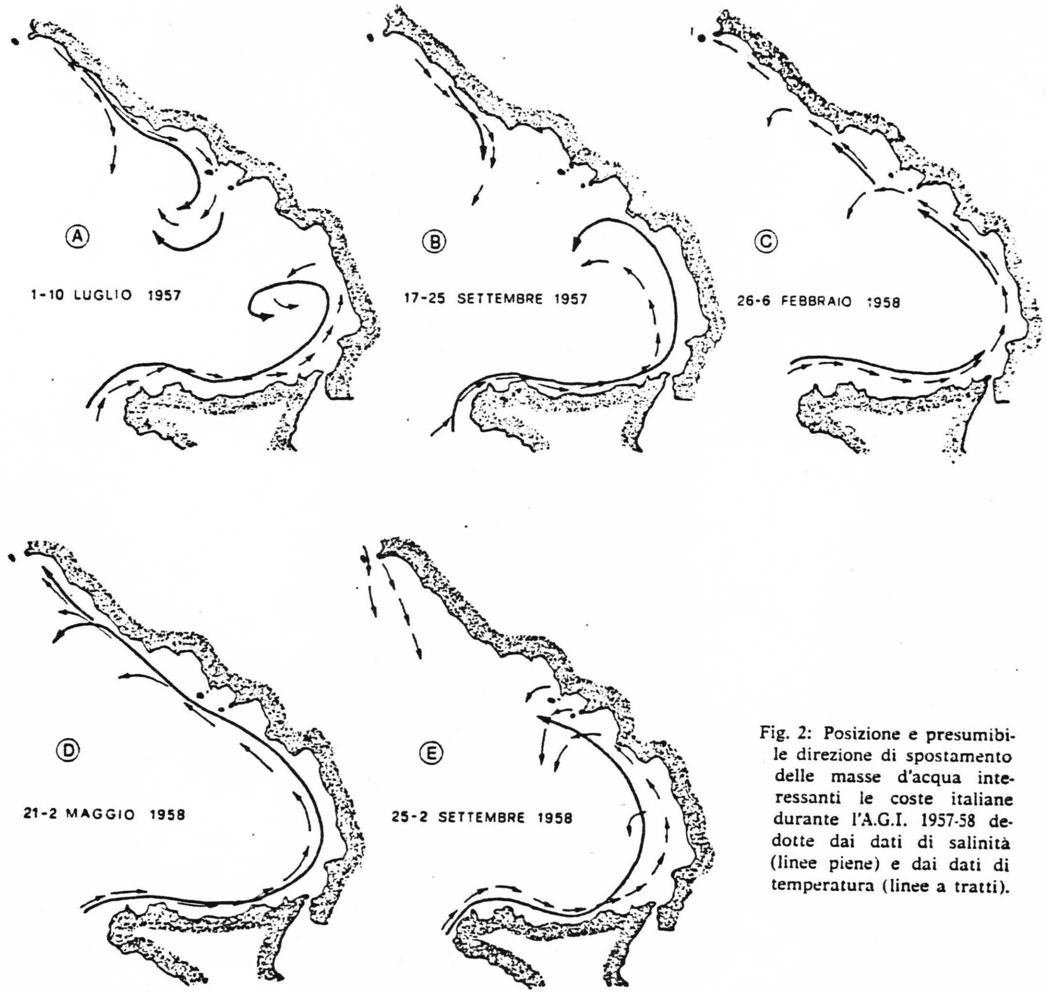


Fig. 2: Posizione e presumibile direzione di spostamento delle masse d'acqua interessanti le coste italiane durante l'A.G.I. 1957-58 dedotte dai dati di salinità (linee piene) e dai dati di temperatura (linee a tratti).

Figure 11. General circulation of the coastal waters of the southwest Italian coast. (De Maio and Moretti, 1973)

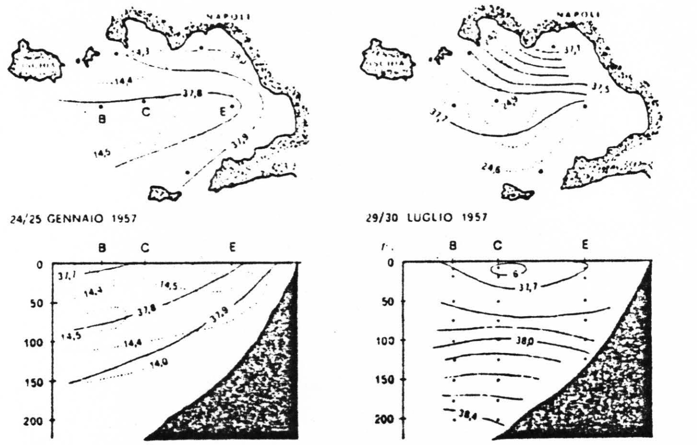


Fig. 6: Distribuzione superficiale di T e di S nel Golfo di Napoli in gennaio e luglio 1957. In basso corrispondenti sezioni verticali secondo le stazioni B, C. E.

Figure 12. Distribution of temperature and salinity showing evidence of upwelling (De Maio and Moretti, 1973).

thermocline at between 50 and 100 meters. However, little mixing of the deep waters appears, as the water below 100 meters remains remarkably stable throughout the year. This coastal water is relatively high in phosphate, which may indicate the presence of upwelling, as the nearshore waters are almost free of phosphate. More recent data collected from the various research projects may clarify the circulation in the bay, and could in turn be used to determine mixing processes of offshore and coastal waters.

C. Nutrients, Oxygen, Salinity, Temperature and pH

A recent study of the nutrients in the Bay of Naples has been made by the Zoological Institute. Only one month of data were available, the month of March, 1975. These data show a deficiency in the ratio of nitrogen to phosphate, which would

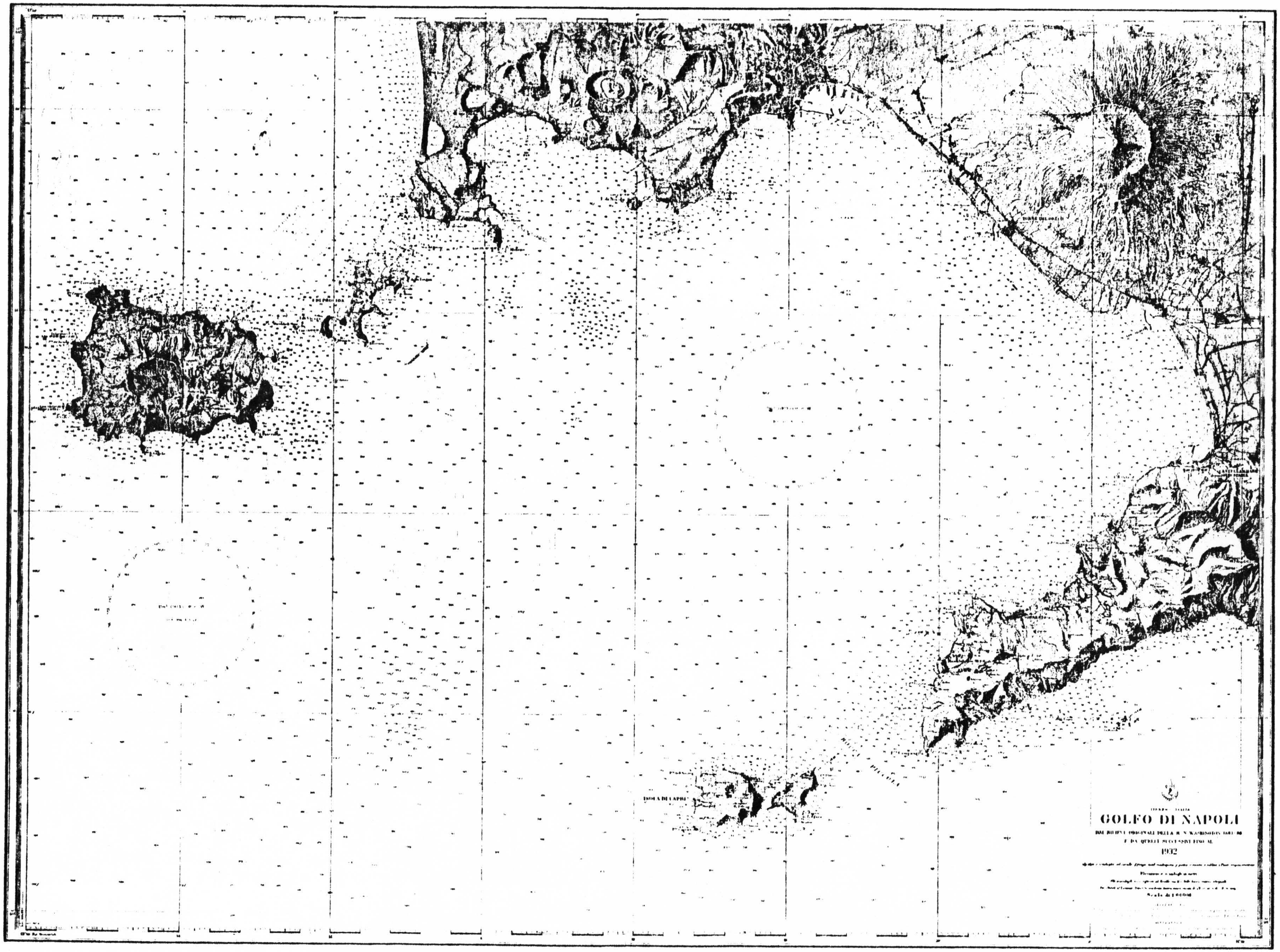


Figure 13.

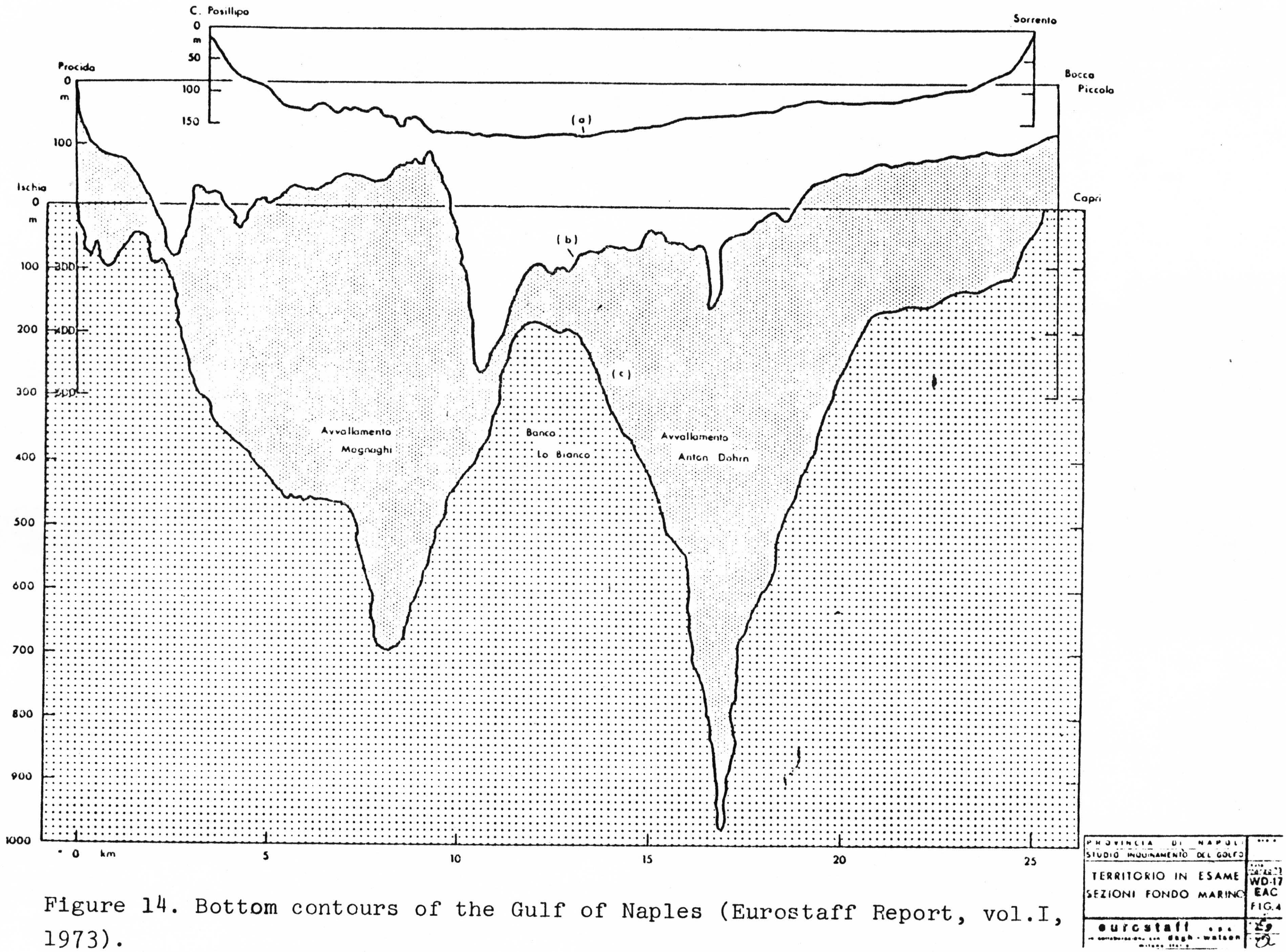


Figure 14. Bottom contours of the Gulf of Naples (Eurostaff Report, vol.I, 1973).

indicate, as is seen in many inshore areas, that nitrogen is the limiting nutrient for photosynthesis. Surface phosphate values offshore from the Port of Naples had .0 - .26 ugAt/L phosphorous and 0.31 to 0.10 ugAt/L nitrogen. About two miles off the coast, the phosphorous was zero and the nitrogen was 0.16. In Potswoli Harbor the phosphorous was 0.32, while nitrogen was 0.16. In the center of the Bay of Naples, the values were between the values listed above and zero. In all areas, the nutrients increased or decreased with depth to a maximum value of phosphorous 0.5, and nitrogen 0.6. There was no noticeable general trend with depth and the average values at depth were about half of the maximum values.

Oxygen values were generally near saturation, even in the inshore areas. This would indicate that eutrophication was not present and is supported by the relatively low values of nutrients found in the water column. A review of the nutrients reported by Hapgood (1960) and summarized by Carrada and Rigillo-Troncone (1973) do not indicate any significant changes with time.

The salinity of the Bay of Naples is typical of the higher salinity waters of the Mediterranean. Figure 15 shows the average salinity profile which shows a slightly lower value along the shores. This latter suggests that the high salinity Gulf water mixes rapidly with the runoff and sewage from land. Figure 16 illustrates the effect of upwelling which occurs as the more dense water is transported up the canyons of the central part of the bay.

All oxygen values available within the scope of this investigation indicate saturation. The presence of low nutrients and high oxygen suggests that the indigenous populations of all

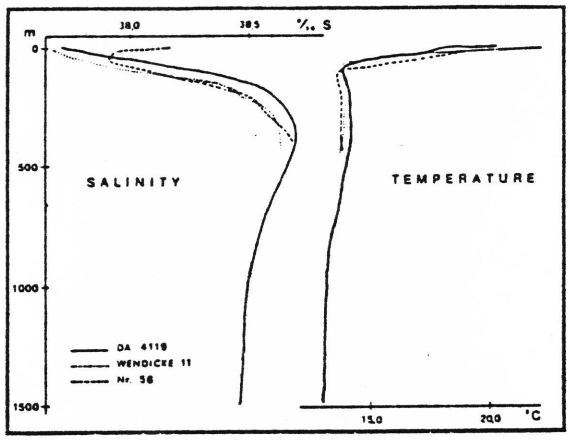


Fig. 4. — Grafico comparativo di alcuni parametri idrografici rilevati nella stessa area da Hapgood (1957), da Wendike (1916) e dalla « Dana Expedition » (1931). (Hapgood, 1957).

Figure 15. Salinity- temperature profile in the Gulf of Naples (Carrada and Rigillo-Troncone, 1973).

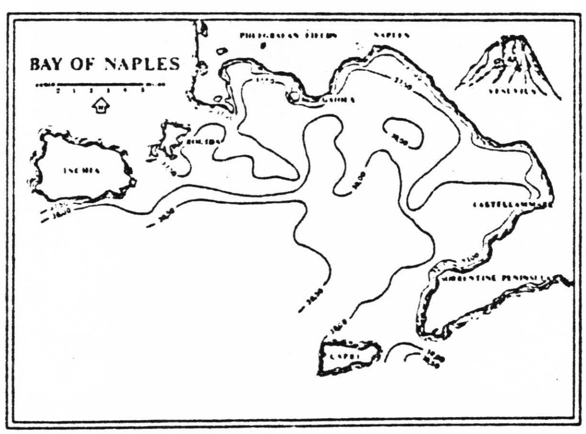


Fig. 8. — Salinità ($S‰$) delle acque di fondo del Golfo di Napoli (Puri, Bonaduce e Malloy, 1964).

Figure 16. Salinity contours in the Gulf of Naples (Carrada and Rigillo-Troncone, 1973).

organisms are somewhat at equilibrium with oxygen exchange at the air/water surface. The recent data of the Zoological Station show a slight decrease in oxygen with depth in the deeper parts of the Gulf. This is typical of most deep water areas. The oxygen does not decrease more than one part per million and there is no indication of eutrophication as a result of the sewage and fresh water input. The data of Carrada et al. (1973) (Fig. 17), Paoletti (1975) (also see section on sewage) and others indicate by oxygen and pH data, that the effluent along the shores is diluted or transported to near background within two to four kilometers from the coast or origin of the effluent. Even in the most concentrated area of effluent, the oxygen is near saturation and the salinities only a few parts per thousand less than background.

The hydrogen ion concentration (Fig. 17) shows the same effect as salinity and oxygen. There is no appreciable ecological difference as related to the sewage impact.

Unfortunately we found no definitive data on the Naples Harbor area. Carrada (1974) measured hydrographic features outside of the harbor but did not report inside the harbor.

Generally, the ecological effect of the various effluents is restricted to a zone adjacent to the shoreline. The wind mixing, current transport is quite large, which restricts the zone of significance. There is no evidence that these effects are noted in the main body of the Gulf or outside a zone of approximately four Km from the sewage effluent.

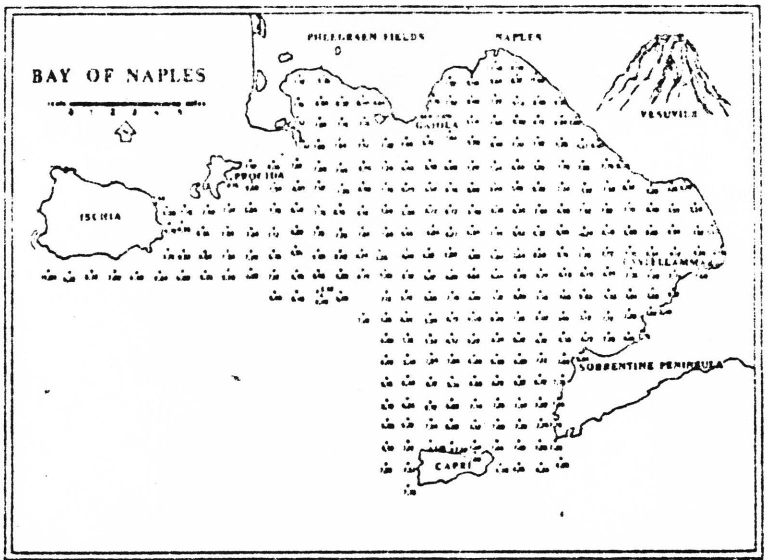


Fig. 6. — Ossigeno disciolto (mg/l) nelle acque di fondo del Golfo di Napoli (Puri, Bonaduce e Malloy, 1964).

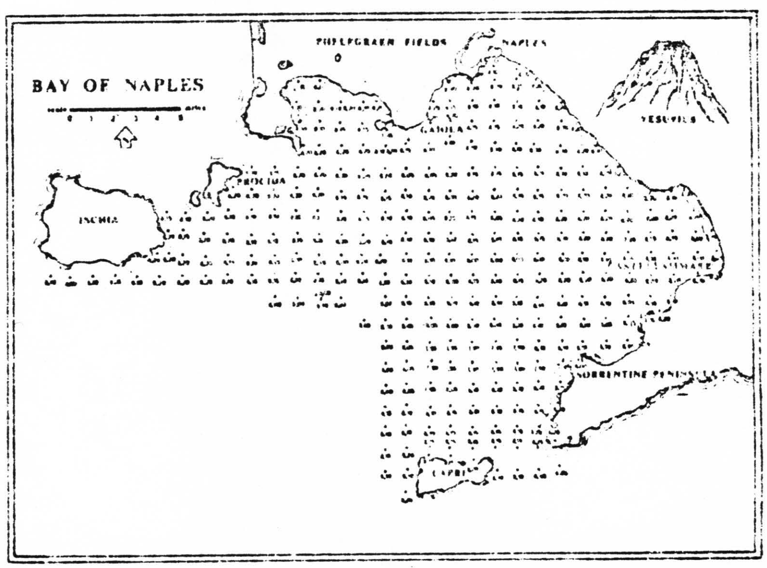


Fig. 7. — pH delle acque di fondo del Golfo di Napoli (Puri, Bonaduce e Malloy, 1964).

Figure 17. Oxygen and pH values in the Gulf of Naples (Carrada and Rigillo-Troncone, 1973).

III. Urban Development and Impact on the Gulf

The population increase of Naples with time, shown in Figure 3 is indicative of the rate of urgan growth of the city. Presently, the population of the region indicates a megalopolis that extends along most of the shoreline of the Gulf of Naples. The Port and its industrial center and the industry at Coroglio has been surrounded by the urgan development. Thus the industrial airborne wastes affect the surrounding areas and after a rain may be significant to the local runoff pollution. The air pollution, which is present from the Port industrial area (Fig. 18) is significant, and must affect the health of the surrounding inhabitants.

The concentration of people within the area (Fig. 18) has increased solid waste loading, much of which is carried away, but a small percentage persists along the streets. The leaching of metals of copper and zinc, asphalts from the roofs, metals from the paints, erosion of the cars on the streets, the grinding of solid materials by the tires of autos, excrements of dogs, cats and occasionally man, and the droppings of the birds, etc. all contribute to the runoff pollution of the area. It is possible that much of the coliform contamination of the area results from street runoff after a rain. The same material will be airborne as dust during dry periods to increase human contact and produce allergic responses in man.

Another aspect of contamination is the wind disbursal of aerosols from coastal waters. High winds will remove surface waters from waves along the bay which acts as an aerosol to be blown inland. Pollution of the water surface can thus be taken back to land.

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Figure 18.

Capri

The authors spent two weekends at Capri as the guests of the Mayors of Capri and Anacapri. Unfortunately, the notes of this part of the program were lost at the Rome airport and therefore the detailed coverage of the total ecology of man's use of the Island of Capri cannot be provided at this time. However, there are aspects of the Island that can be used to illustrate examples of man's impact.

Table 5 provides an outline of the tourist's daily and overnight use of the Island. The resident population is approximately 12,000 and therefore the visitor population has a very great impact on the Island. There are three sewage treatment plants on the Island. All the plants dispose effluent into the surrounding waters. The one plant on the Marina Grande side sends its effluent into the harbor. The Anacapri effluent runs over the cliff a short distance from the Blue Grotto (See Figure 19-6). Table 5 shows how many people pass by this effluent each month as they visit the Blue Grotto. The number of private boats using the waters of the Island are significant.

Thus the Island has a considerable amount of sewage entering the waters. Most of this sewage is treated only by primary treatment or Imhoff chamber. During periods of large tourist activity all the treatment plants overreach their capacity and the treatment plant is bypassed. This is also true during heavy rainfall as the plants have no capacity to take the larger runoff.

Solid wastes are a problem that all small overpopulated islands must overcome. One of the problems on the Island is related to the

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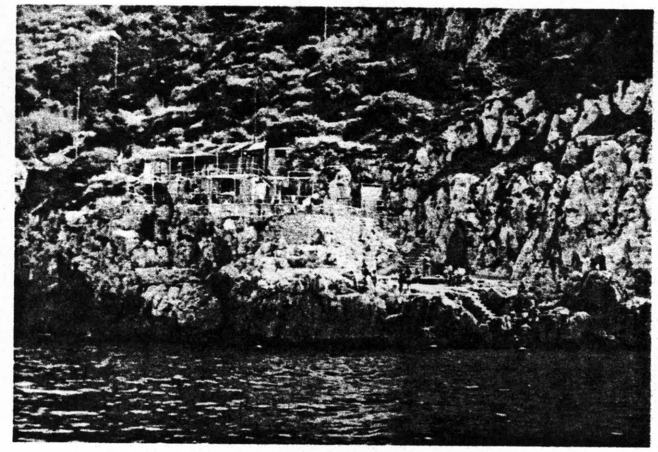

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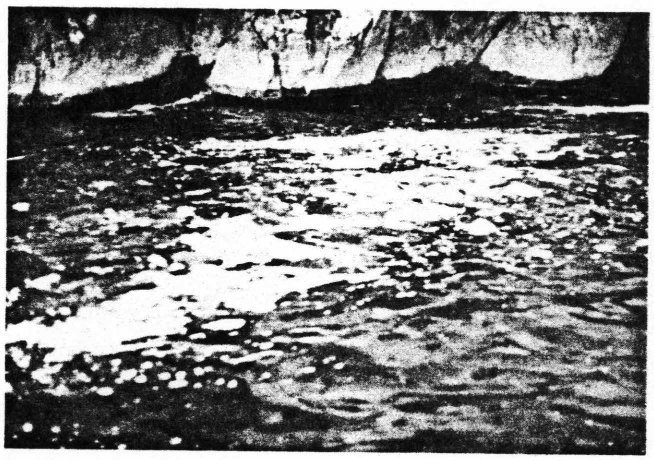

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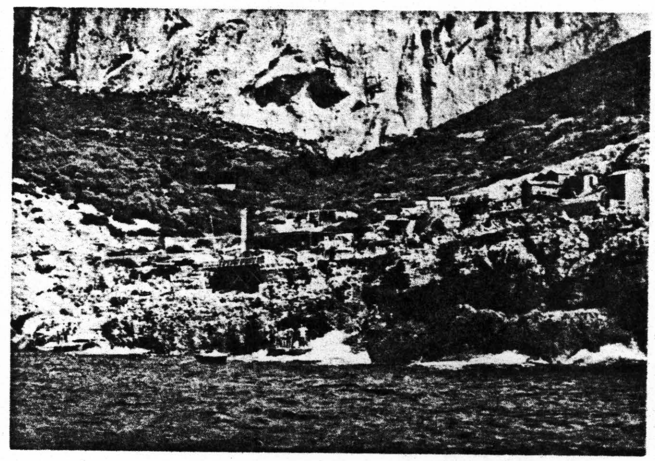

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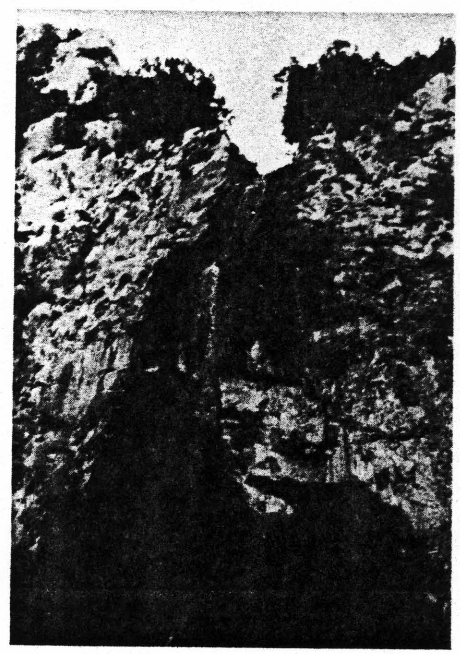

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Figure 19.

Table 5. Boating and tourists at Capri

AZIENDA AUTONOMA DI CURA SOGGIORNO E TURISMO

ISOLA DI CAPRI

DATI STATISTICI SUL MOVIMENTO FORESTIERI IN CAPRI ED ANACAPRI

1975

MESI	TOTAL: MOVIMENTO PORTUALE Passeggieri	Navi	OVERNIGHT: ARRIVI Ital.	Stran.	Tot.	VISITORS: PRESENZE Ital.	Stran.	Tot.
GENNAIO	42.743	1.201	177	236	413	747	597	1.344
FEBBRAIO	52.059	1.114	190	229	419	412	520	932
MARZO	108.802	1.736	1.348	1.164	2.512	3.672	3.755	7.427
APRILE	180.644	2.474	1.923	1.925	3.848	5.288	7.725	13.013
MAGGIO	213.172	2.702	3.373	4.106	7.479	8.593	19.383	27.976
GIUGNO	238.977	3.600	2.427	4.992	7.419	10.731	26.008	36.739
LUGLIO	302.435	4.018	4.185	5.508	9.693	29.463	29.706	59.169
AGOSTO	709.931	5.914	5.414	4.376	9.790	53.157	27.559	80.716
SETTEMBRE	394.179	4.226	4.186	5.825	10.011	17.180	28.526	45.776
OTTOBRE	169.849	2.382	496	2.404	2.900	1.802	12.749	14.551
NOVEMBRE	66.659	1.436	245	328	573	768	1.519	2.287
DICEMBRE	53.244	1.386	516	331	847	1.157	763	1.920
TOTALE	2,532.694	32.189	24.480	31.424	54.904	132.970	158.880	291.850

Table 5 continued

<u>Visitations for 1973</u>

MESI	Gr. AZZURRA	VILLA JOVIS	SAN MICHELE
GENNAIO	994	350	1.414
FEBBRAIO	799	174	1.252
MARZO	8.638	535	3.048
APRILE	26.965	3.947	14.936
MAGGIO	55.351	2.254	18.888
GIUGNO	62.456	2.490	24.362
LUGLIO	67.157	2.137	23.380
AGOSTO	108.157	2.175	26.270
SETTEMBRE	33.405	1.079	11.279
OTTOBRE	12.703	659	6.893
NOVEMBRE	7.674	340	--
DICEMBRE	935	176	--
TOTALE	374.234	16.316	131.722

use of plastics. Plastic bags are not biodegradable and therefore if they are disposed into the waters around the Island they will accumulate. This is demonstrated by the photographs in Figure 19-1,3,5).

Capri has other problems related to the availability of fresh water, the exhaust fumes of ships and vehicles, the by-products of the large influx of tourists in the summer, the sewage treatment plants, energy, etc. The Island could be used as a good model of an impacted environment and, thus, be used to develop the criteria for environmental evaluation and control. It is a beautiful Island steeper in history and worthy of concern.

IV. Street Runoff

The data at hand will not permit a complete analysis of the effects of rainfall and its contribution of street runoff to the coastal environments. It would be necessary to determine the major areas of runoff along the coast and to estimate the numbers of street miles. The impact of man's activities on contamination of the streets is considerable and arises from the leaching of metals of roofs and cars such as copper or chromium; hydrocarbons from the roofs, streets and cars (see Fig. 20); the washing of airborne pollutants from the war by the rain; the activities of man as he uses the streets. Animals also have a great impact. It has been estimated in the U.S. that for each person (in an average city) approximately 31 kilos of feces will be deposited by dogs on the streets per year.

A publication by Sarter and Boyd (1972) provides values for pollutants as averaged from 7 cities in the United States. The

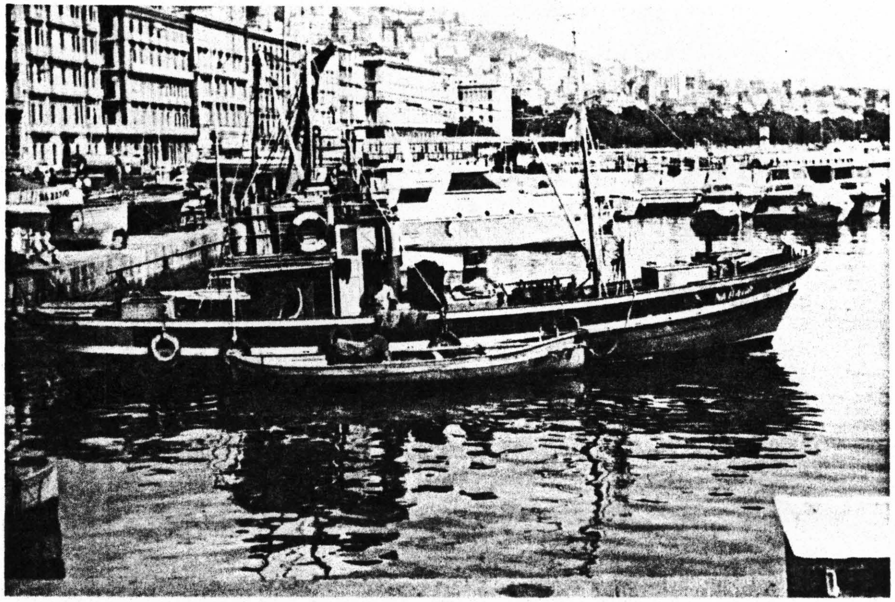

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Figure 20.

Table 6. Street source of pollutants (Sartor and Boyd, 1972).

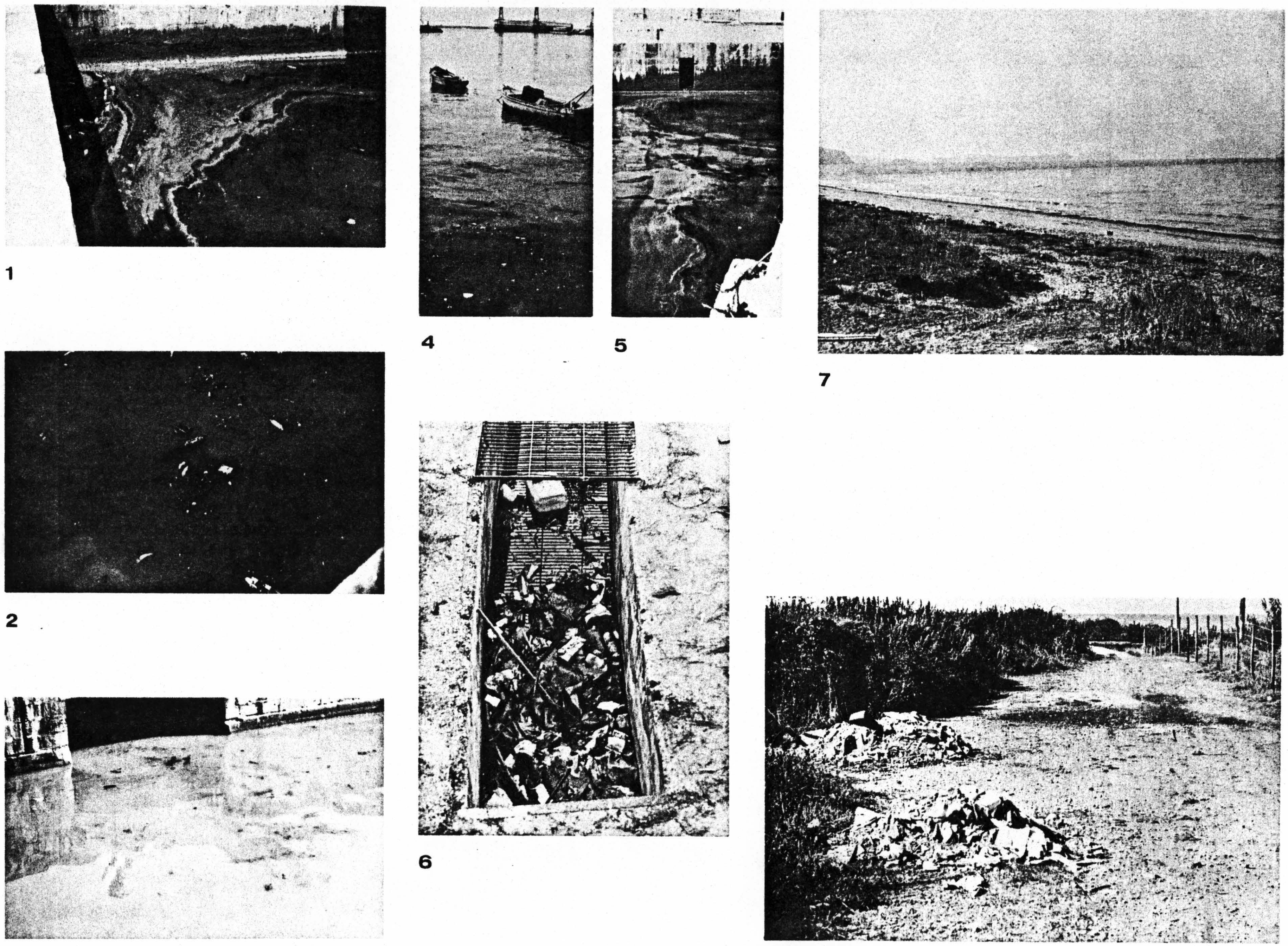
MEASURED CONSTITUENTS	WEIGHTED MEANS FOR ALL SAMPLES (Kg/curb Km)
Total Solids	1017.0
Oxygen Demand	
BOD_5	9.8
COD	69.0
Volatile Solids	72.6
Algal Nutrients	
Phosphates	.7
Nitrates	.068
Kjeldahl Nitrogen	1.5
Bacteriological	
Total Coliforms (org/curb Km)	158.4×10^{9}
Fecal Coliforms (org/curb Km)	9.0×10^{9}
Heavy metals	
Zinc	.47
Copper	.14
Lead	.41
Nickel	.002
Mercury	.053
Chromium	.01
Pesticides	
p,p-DDD	48.7×10^{-6}
p,p-DDT	44.3×10^{-6}
Dieldrin	17.4×10^{-6}
Polychlorinated Biphenyls	799.0×10^{-6}

values are related to a rainfall frequency of 1.3 cm of rain at intervals of 5 days, and in which the average street is cleaned once a week with a mechanical street cleaner. Table 6 shows the amounts of pollutants washed from the average size streets in Kg per curb Kilometer.

These contamination values can be multiplied by the number of rains of 1.3 cm or better per year and by the number of Kilometers of streets. The numbers would be appreciably greater if no mechanical street cleaning is performed on a routine basis. The reference is included as a guideline to show the magnitude of street runoff effect on adjacent bodies of water. For example, if there are 5000 linear Km of streets draining into the Gulf waters, a 1.3 cm rain would wash 700 Kilos of copper, 2100 Kilos of lead, 8×10^{14} total coliforms, etc. off the roads. These data could then be compared with the amounts entering from the sewage, if the two could be separated.

V. Solid Waste

It is difficult to determine the environmental impact of solid waste. One could start with the average figure used in the United States, that each person generates approximately seven pounds of solid waste per day. This would produce about seven million pounds per day per each million of population. Figures 19 and 21 illustrate the solid wastes in the area of the Gulf of Naples. In general such solid wastes except for excreta, only affect the esthetic or cosmetic aspects of our environment. The plastics that accumulate along the shore of the Island of Capri or along the beaches of the Gulf of Naples



1 2 3 4 5 6 7 8

Figure 21.

really do not harm the total ecology but do hurt the esthetic feeling of the inhabitants and, especially, the visitors. There is direct evidence that the plastics are ingested by some fish, turtles, and other organisms and may cause death as they impair the normal metabolic functions. However the general aspect is one of cosmetic appearance. Education of the people, enforcement of existing laws, and the discouragement of the use of plastics, the most general offender, will alleviate much of the cosmetic effect of solid waste.

The other consideration must be made in relation to solid waste. The solid by-product of sewage and industrial waste must be disposed of by methods which will not affect the ground waters or land use. Also, solid wastes must not be placed in the marine waters without evaluation of the environmental and cosmetic effects. This is especially true of those solid waste materials that provide floating residues or are not effectively biodegraded by microorganisms. Sanitary landfills must be situated so that the leaching of the wastes does not affect surrounding waters.

VI. Sewage Effluent

Figure 22 identifies the numerous sewage effluents that enter directly along the shore into the Gulf of Naples. Such diffuse type of sewage disposal has grown throughout the centuries with the city. There is a considerable amount of information available on the direct impact of the sewage outfalls to the beaches.

The Cassa della Mezzogiorno produced Figure 23, which outlines the sewage system and types of disposal for the present and

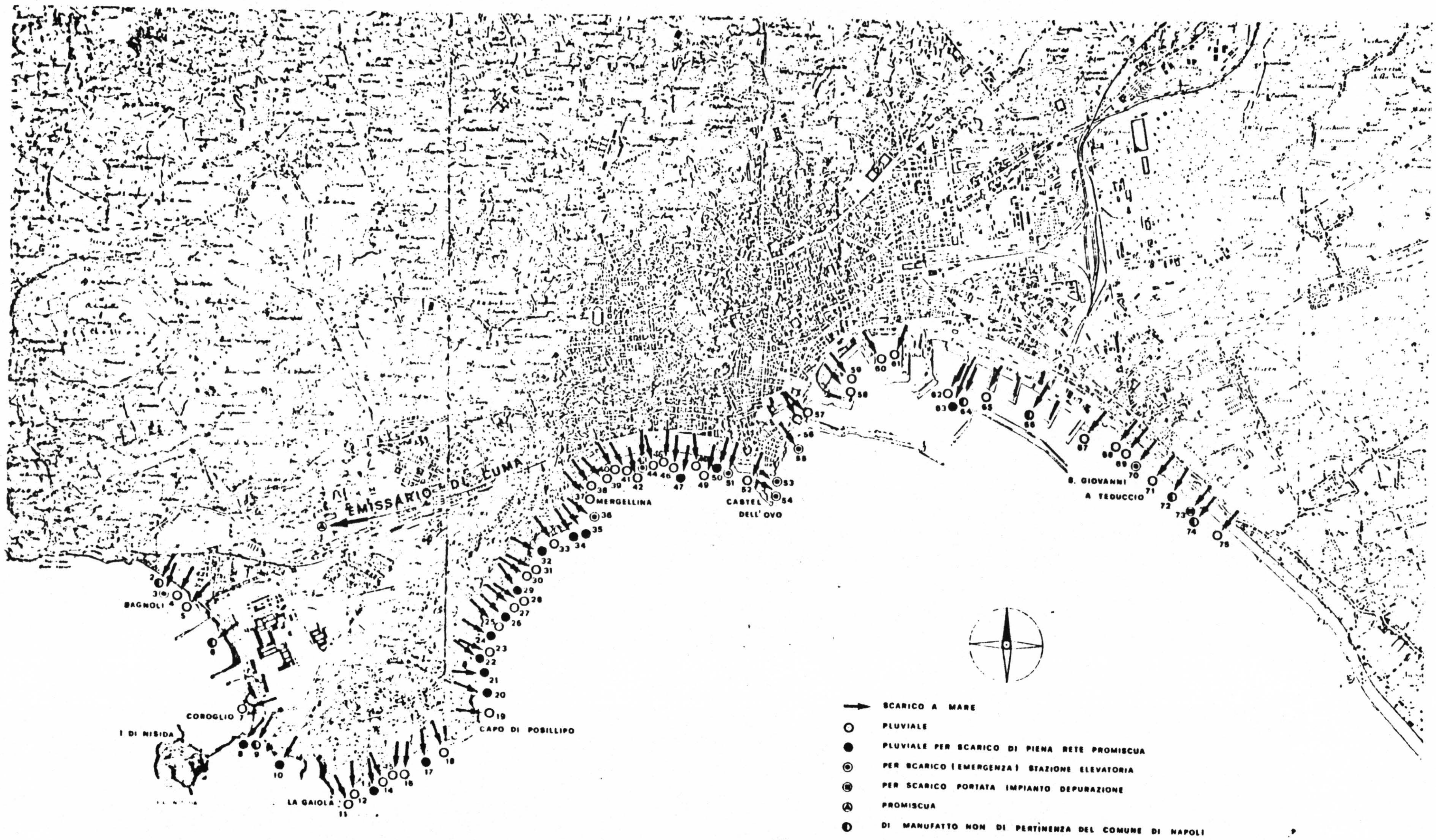


Figure 22. Site of sewage effluents in the Gulf of Naples (Mendia et. al., 1976).

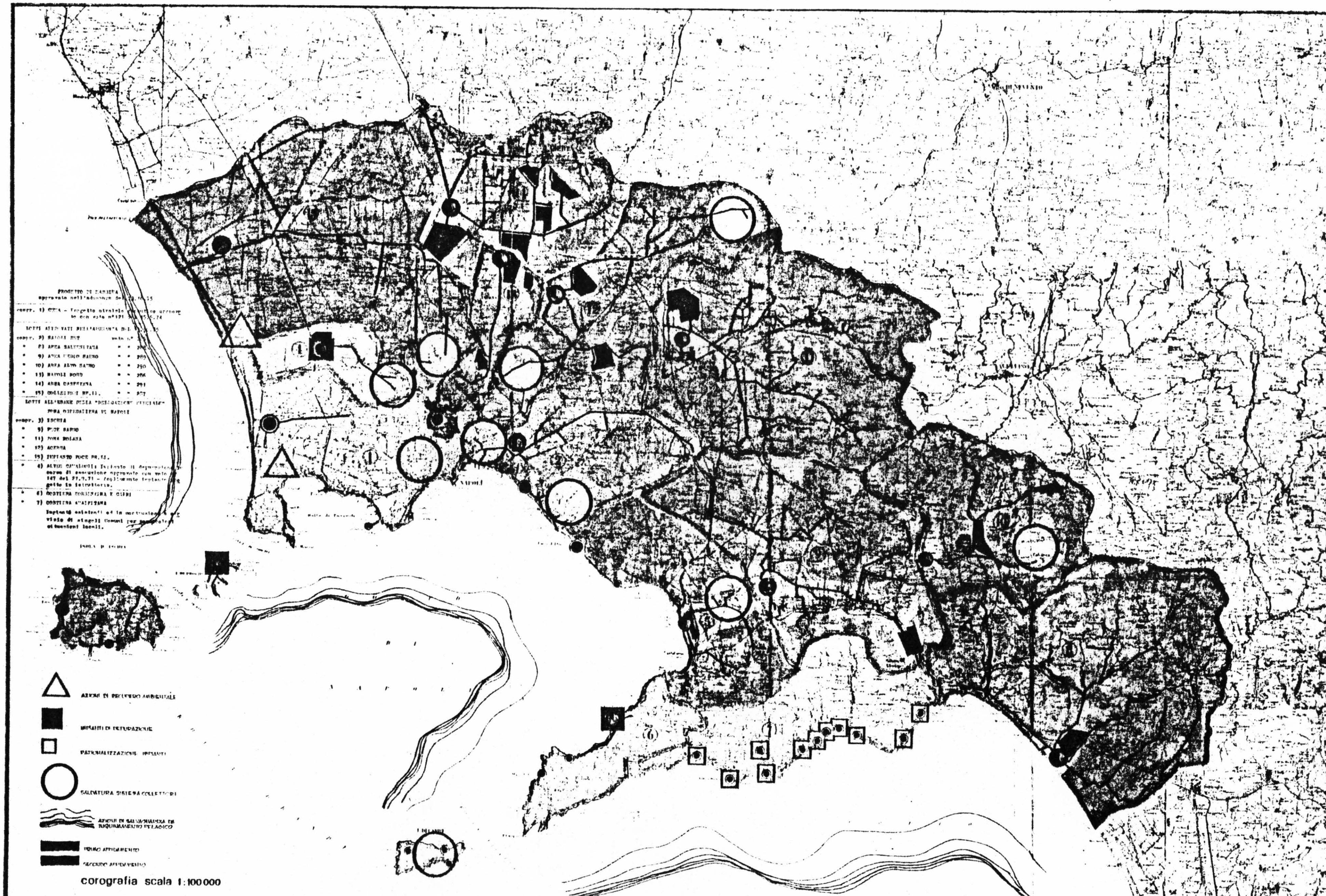

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Figure 23.

planned for future. The Eurostaff Report fully covers representative portions of the effluents as shown in Table 7 that cover a large part of the shoreline of the Gulf. Paoletti (1973 and 1975) Figures 24-25, and Carrada (1974), Figure 26, reported on the offshore distribution of sewage adjacent to outfalls. The Eurostaff Report (Figure 27) shows the disbursion of sewage relative to wind and currents.

These data can be used to determine the impact of the sewage on both the coastal environment and the Gulf of Naples. While it is not possible to cover all the data in this report, the material was analyzed relative to ocean outfalls in the section entitled Waste Treatment Alternatives.

The sewage outfalls in Naples Harbor are shown in Figure 31.

VII. Industrial Development

Time did not permit an analysis of all the industrial effects of pollution per se. However, observations were made that can be used to outline the extent of industrial effects on the environment.

The first obvious effect of industrial impact is to increase the urban development for factory employee housing. The employees of the industrial area generally live in the adjacent urban areas, thus adding to the urban pollution load. Most of the industries release untreated wastes into the local rivers or sewage lines. Those industries with gas wastes, pass untreated vapors and solids into the atmosphere. The gas materials, depending on the wind, may either return directly to the surrounding area or be carried inland or seaward for many miles. During certain meteorological

Table 7. Water quality data of several areas of the coast near Naples (Hydrological Tables).

Tabella n. 16 - VALORI DELLE DETERMINAZIONI ANALITICHE SUI CAMPIONI PRELEVATI DAL FIUME SARNO

STAZIONE N°1 UBICAZIONE PONTE FOCE - FERROVIA

Il prelievo del 29.9.72 è stato effettuato dopo una giornata di intensa pioggia.

N° del campione	1 S	2 C	3 D	4 S	5 C	6 D	7 S	8 C	9 D	10 S	11 C	12 D	13 S	14 C	15 D
Data del prelievo	22	9	72	9	9	72	2	10	72	6	10	72	9	10	72
Temperatura dell'aria (°C)	25	25	25	1	21	21	21	21	21	22	22	22	20	20	20
Temperatura dell'acqua (°C)	15,80	15,80	15,80	14	14	15	13,5	13,5	15	13,70	13,20	15	13,40	13,40	14,50
p. H.	6,70	6,50	6,30	6,15	6,45	7,20	6,20	6,55	6,85	6,50	6,45	7,00	6,20	6,90	7,00
Risultati in mg/l.															
B.O.D. 5	81,80	81,80	101	8,9	70,2	83,6	70	71,2	112	70	70	85	70	112	112
C.O.D.	100	100	200	95	85	100	100	200	260	80	80	100	90	200	280
O.D.	3,92	3,72	2,00	5,22	5,12	3,75	7,80	4,00	4,00	4,20	4,20	3,70	7,08	4,00	4,00
Ammoniaca (NH_4^+)	0,50	0,50	0,25	0,50	0,50	0,40	0,75	0,75	0,50	0,60	0,65	0,70	0,80	0,80	0,60
Nitriti (NO_2^-)	0,10	0,05	0,2	0,05	0,05	0,10	0,05	0,05	0,05	0,05	0,05	0,20	0,05	0,06	0,06
Nitrati (NO_3^-)	1,50	2,00	3,00	1,30	1,30	1,70	1,50	1,50	1,50	1,50	1,50	1,80	1,50	1,60	1,50
Fe^{2+}	0,002	0,002	0,00[illegible]	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
Stabilità al blu di Metilene (a 5 gg)	aerobio			aerobio			aerobio			aerobio			aerobio		
Colore	3,00	3,00	50	5,00	5,00	40	5,00	5,00	10	5,00	5,00	30	5,00	5,00	10
Cromo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Nota: S - Riva sinistra
D - Riva destra
C - Centro Fiume
con le spalle alla sorgente

N.B. Le sostanze sedimentali specie alla riva destra sono mg. 2‰ e vi è un forte quantitativo di schiuma. Si nota presenza di carbonati.

STAZIONE 1 - UBICAZIONE PONTE FOCE - FERROVIA -

N° del campione	16 S	17 C	18 D	1 S	2 C	3 D	4 S	5 C	6 D	7 S	8 C	9 D	10 S	11 C	12 D
Data del prelievo	13	10	72	16	10	72	20	10	72	27	10	72	1	12	72
Temperatura aria (°C)	21	21	21	20	20	20	18	18	18	17,20	17,20	17,20	18	18	18
Temperat.acqua (°C)	13,10	13,10	14	13,10	13,10	14	13	13	15	13	13	15	14	14	15
p.H.	6,20	6,20	7,00	6,80	6,80	7,12	6,8	6,8	6,10	6,80	6,80	6,30	6,20	6,50	6,55
Risultati in mg/l															
B.O.D. 5	81	81	110	88	88	101	80	80	88	80	80	88,[illegible]	112,4	106	111,4
C.O.D.	110	110	200	90	90	166	92	92	140	95	95	172	170	160	168
O.D.	4,[illegible]0	4,00	3,00	4,00	400	2,95	4,00	4,00	3,50	4,00	4,00	3,28	1,20	1,20	1,00
Ammoniaca (NH_4^+)	0,50	0,50	0,75	0,75	0,75	1,60	0,75	0,75	2,00	0,75	0,75	2,00	1,50	1,00	0,75
Nitriti (NO_2^-)	0,06	0,06	0,10	0,01	0,01	0,03	0,01	0,01	0,05	0,01	0,01	0,05	0,20	0,15	0,10
Nitrati (NO_3^-)	1,50	1,50	1,50	1,50	1,50	2,00	1,00	1,00	1,00	1,50	1,50	1,50	2,00	1,80	200
Fe^{2+}	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002	0,002
Stabilità al blu di Metilene (a 5 g)	aerobio			aerobio			aerobio			aerobio			aerobio		
Colore	10	10	50	3,00	3,00	8,00	5,00	5,00	40	5,00	5,00	60	[illegible],00	5,00	8,00
Cromo	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0

N.B. Le sostanze sedimentali specie nella riva destra sono mg.2 ‰ - si nota presenza di forte quantitativo di schiuma e carbonati.

Table 7. continued.

STAZIONE N. 2 - UBICAZIONE PONTE FINE CANALE BOTTARO - PRELEVAMENTI SOLO AL CENTRO
IL PRELIEVO DEL 29.9.72 E' STATO EFFETTUATO DOPO UNA GIORNATA DI PIOGGIA INTENSA

N° del campione	1	2	3	4	5	6	7	8	9	10
Data del prelievo	[illegible]-9/72	29-9/72	[illegible]-10/72	6-10/72	9-10/72	13-10/72	16-10/72	20-10/72	27-10/72	1-12/72
Temperat.aria (°C)	20,2	21	21	20	21	20	20	18,20	17,20	18
Temperat.acqua (°C)	16	14	13,20	14	14	15	13,50	13,20	13,20	14
p.H.	6,30	6,45	7,00	6,50	7,15	6,50	6,55	6,60	6,70	6,50
Risultati in mg l.										
B.O.D.5	59,20	93	115	93	110	93,4	88	95	97	105
C.O.D.	90	130	[illegible]93	140	210	120	100	125	120	156
O.D.	7,20	2,80	3,00	[illegible],80	3,84	[illegible],50	3,32	2,80	2,40	1,52
Ammoniaca (NH_4^+)	0,70	0,60	[illegible],50	0,60	2,00	0,60	0,75	1,00	1,2[illegible]	1,35
Nitriti (NO_2^-)	0,10	0,03	0,03	0,03	0,03	0,05	0,05	0,0[illegible]	0,0[illegible]	0,03
Nitrati (NO_3^-)	1,50	1,30	1,50	1,80	1,50	1,50	1,70	1,50	1,50	1,70
Fe^{2+}	0,003	0,003	0,003	0,003	0,003	0,00[illegible]	0,00[illegible]	0,00[illegible]	0,003	0,003
Stabilità al blu di Metilene (a 5 g.)	-	-	-	-	- aerobio		-	-	-	-
Colore	3,00	3,00	10	3,00	10	10	3,00	5,00	5,00	5,00
Cromo	0	0	0	0	0	0	0	0	0	0

N.B. - Il 16.10.72 vi era poca corrente. Il 20 e il 27.10 si sono notati prodotti oleosi e catramosi.

STAZIONE N.3 - UBICAZIONE PONTE ALL'ALTEZZA DEL MACELLO DI POMPEI

(i prelievi sono stati effettuati al centro ad eccezione del primo. Quello del 29.9.72 dopo una giornata intensa di pioggia.)

N° del campione	1 S	2 D	3	4	5	6	7	[illegible]	9	10	11
Data del prelievo	22 - 9 - 72		[illegible]/72	2-10/72	6-10/72	9-10/72	13.10/72	[illegible]/72	[illegible]/72	[illegible]/72	1-12/72
Temperat.aria (°C)	19	19	20	21	21	20	21	20	15,20	17	16
Temperat.acqua (°C)	15	15	13,80	14	14	14	15	13,20	13	13,20	14
p.H.	6,40	6,20	6,70	7,00	6,70	7,00	6,50	6,60	6,50	6,50	6,55
Risultati in mg l.											
B.O.D. (a 5 g.)	87	73,20	53,2	83	70	64	90	102	93	93,6	116,6
C.O.D.	100	100	90	320	120	320	120	132	134	127	210
O.D.	3,40	3,80	6,60	3,40	4,20	1,04	3,40	1,88	2,80	2,76	1,44
Ammoniaca (NH_4^+)	0,50	0,50	0,40	0,50	0,45	0,60	0,45	0,25	0,50	0,75	1,25
Nitriti (NO_2^-)	0,05	0,07	0,02	0,03	0,03	0,03	0,02	0,03	0,03	0,05	0,10
Nitrati (NO_3^-)	2,00	2,00	1,50	1,80	1,50	1,70	1,40	1,50	1,80	1,60	1,80
Fe^{2+}	0,003	0,003	0,003	0,00[illegible]	0,003	0,003	0,003	0,003	0,003	0,003	0,003
Stabilità al blu di Metilene (a 5 g.)	-	-	-	-	-	aerobio	-	-	-	-	-
Colore	20	3,00	30	10	20	12	10	5,00	3,00	5,00	10
Cromo	0	0	0	0	0	0	0	0	0	0	0

Nota: S - Riva Sinistra
D - Riva Destra

Table 7. continued.

STAZIONE N. 4 - UBICAZIONE - PONTE SUL CANALE S.ANTONIO
ALLA CONFLUENZA COL FIUME SARNO - PRELEVAMENTO AL CENTRO

N° del campione	1	[illegible]	[illegible]	[illegible]					[illegible]	10
Data del prelievo	[illegible]/72	[illegible]/72	2-10/72	[illegible]-10/72	[illegible]-10/72	13-10/72	16-10/72	[illegible]-10/72	[illegible]-10/72	1-12/[illegible]
Temperat.aria (°C)	20,30	21	20	21	20	21	20	[illegible],20	17	18
Temperat.acqua (°C)	16	17	17	17	16	17	16,20	16	16	15,5
p. H.	6,00	6,40	7,50	6,90	7,30	6,70	6,75	6,75	6,75	6,40
Risultati mg/l.										
B.O.D. 5	65,30	93	110	90	110	115	110,3	94	[illegible]	109
C.O.D.	[illegible]	145	200	130	200	230	130	130	130	160
O.D.	[illegible],60	2,80	2,00	3,00	1,70	2,00	2,08	2,64	2,60	1,20
Ammoniaca (NH_4^+)	[illegible],25	0,60	2,00	0,80	1,70	0,60	1,40	0,50	0,50	0,75
Nitriti (NO_2^-)	0,05	0,02	0,03	0,01	0,03	0,05	0,05	0,03	0,03	0,05
Nitrati (NO_3^-)	2,00	1,50	1,00	1,30	1,50	1,30	1,70	1,20	1,50	1,50
Fe^{2+}	0,008	0,008	0,004	0,008	0,009	0,007	0,00[illegible]	0,009	0,007	0,007
Stabilità al blu di Metilene (a 5 g)	-	-	-	-	aerobi	-	-	-	-	-
Colore	5,00	4,00	15	4,00	15	10	5,00	5,00	5,00	10
Cromo	0	0	0	0	0	0	0	0	0	0

N.B. Il 9.10.72 il livello del corso d'acqua era molto basso. Il prelevamento del 29.9.72 è stato effettuato dopo una giornata di intensa pioggia. Si è notata presenza di prodotti oleosi e abbondanza di solidi grossolani costituiti principalmente da detriti della lavorazione del pomodoro e altra verdura.

STAZIONE N°5 - UBICAZIONE PONTE CANALE BOTTARO - LIMITE
PROVINCIA NAPOLI-SALERNO: IL PRELIEVO E' STATO EFFETTUATO DOPO UNA GIORNATA DI INTENSA PIOGGIA

N° del campione	1	2	3	4	5	6	7	8	9
Data del prelievo	29-9/72	2-10/72	6-10/72	9-10/72	13-10/72	16-10/72	[illegible]-10/[illegible]	[illegible]-10/72	1-12/72
Temperat.aria (°C)	21	20	20	21	20	20	[illegible]	17	18
Temperat.acqua (°C)	13,20	13	13	13,10	13,30	13,10	[illegible],20	[illegible],20	13,5
p.H.	6,90	7,10	7,00	7,00	7,00	6,80	[illegible],70	[illegible],70	6,50
Risultati in mg/l.									
B.O.D. 5	[illegible]	111,4	[illegible]	111	87	[illegible]	[illegible]	[illegible]	109
C.O.D.	102	210	100	200	100	140	130	134	158
O.D.	[illegible],12	3,40	[illegible],00	3,20	4,00	2,00	3,00	3,04	1,20
Ammoniaca (NH_4^+)	0,40	0,50	0,40	0,50	0,40	0,50	0,60	0,60	1,10
Nitriti (NO_2^-)	0,02	0,07	0,02	0,05	0,05	0,03	0,03	0,03	0,05
Nitrati (NO_3^-)	1,00	1,50	1,60	1,50	1,70	2,00	[illegible],50	1,50	1,50
Fe^{2+}	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003	0,003
Stabilità al blu di Metilene (a 5 mg)	-	-	-	-	aerobio	-	-	-	-
Colore	[illegible],00	10	[illegible],00	[illegible]0	15	3,00	5,00	[illegible],00	10
Cromo	0	0	0	0	0	0	0	0	0

N.B. Il 9.10.72 il livello del Canale era molto basso.

Table 7. continued.

STAZIONE N. 6 - UBICAZIONE PONTE S. ANTONIO - MASSERIA FIOCCO AL LIMITE PROVINCIA

NAPOLI-SALERNO. IL PRELIEVO DEL 29.9.72 E' STATO EFFETTUATO DOPO UNA GIORNATA DI PIOGGIA INTENSA

N° del campione	1	2	3	4	5	6	7	8	9						
Data del prelievo	29-9/72	2-10/72	6-10/72	9-10/72	13-10/72	16-10/72	20-10/72	27-10/72	1-12/72						
Temperat.aria (°C)	21	20	20	21	20	20	18,40	17,20	18						
Temperat.acqua (°C)	17	17	17	16	16,20	16,80	16	16	15,5						
p. H.	6,55	6,90	7,00	6,70	6,50	6,70	6,50	6,55	6,55						
Risultati mg/l.															
B.O.D. 5	64	111	60	111,2	90	103	98	99,2	89,2						
C.O.D.	124	200	124	180	110	110	125	130	109						
O.D.	5,72	3,28	4,20	3,30	3,40	1,76	2,40	2,20	3,20						
Ammoniaca (NH_4^+)	0,25	0,25	0.30	0.30	0,30	0,25	0,25	0,25	0,80						
Nitriti (NO_2^-)	0,01	0,10	0,01	0,05	0,03	0,30	0,05	0,10	0,05						
Nitrati (NO_3^-)	1,00	1,80	1,60	1,70	1,50	1,70	1,50	1,50	1;80						
Fe^{2+}	0,012	0,012	0,015	0,012	0,012	0,012	0,015	0,012	0,012						
Stabilità al blu di Metilene (a5g)	-	-	-	- aerobio		-	-	-	-						
Colore	5,00	10	5,00	10	10	5,00	5,00	5,00	5,00						
Cromo	0	0	0	0	0	0	0	0	0						

N.B. - Il 9.10.72 il livello del canale era molto basso. Discreta corrente il 16.10.72. Si è notata presenza di prodotti oleosi e di solidi grossolani costituiti per la maggior parte da detriti della lavorazione del pomodoro e altre verdure.

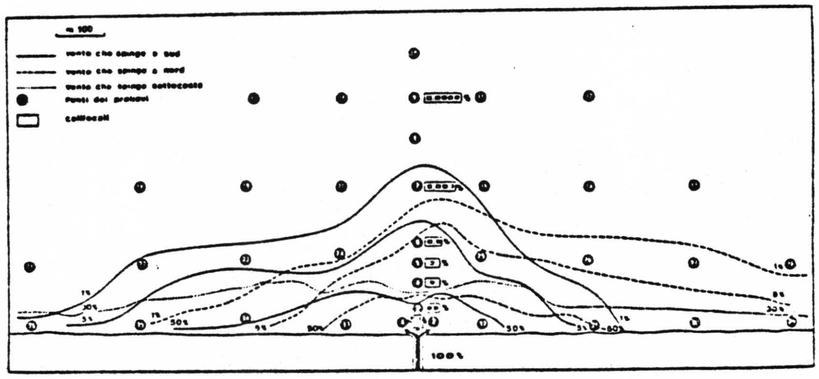


Fig. 17. - Curve di diffusione dei silicati in mare. Valori in % rispetto alle concentrazioni di essi nel collettore di Cuma. Valori medi di 8 giornate di lavoro.

TABELLA IV

Silicati e colifecali nel collettore di Cuma e nelle acque antistanti. Valori medi di 8 giornate di lavoro.

Parametro studiato	Collettore di Cuma	Punti 1, 2, 3	Punto 4	Punto 5	Punto 6	Punto 7	Punti 8, 9, 10
Silicati: micromoli/l Colifecali: in 100 c.c.	141 1.800.000.000	89.5 510.000.000	47.5 172.000.000	34.5 61.000.000	21.4 9.000.000	3.9 54.000	1.8 3.600
Silicati % Colifecali %	100% 100%	63% 28%	33% 9%	23% 3%	14% 0,5%	2% 0,003%	11% 0,0002%

Figure 24. Distribution of silicates and coliforms at Cuma (Paoletti et al., 1973.).

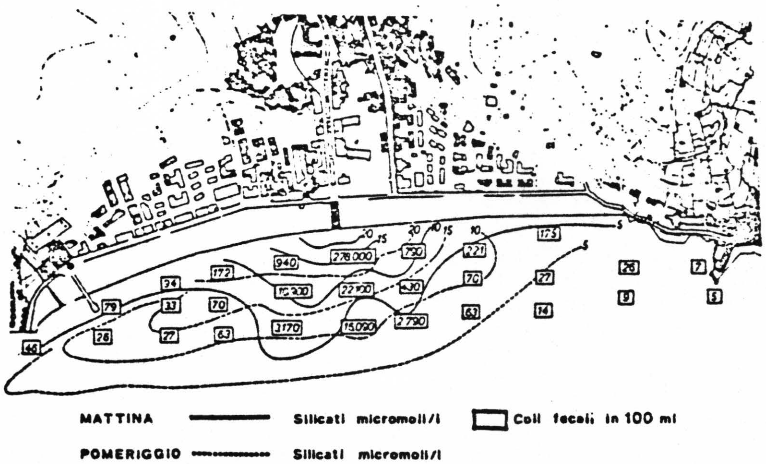


Fig. 8. - Esempio di diversa direzione dell'inquinamento del mare provocato dal fiume Reginna quando riceveva le acque fecali di Maiori. Condizioni prevalenti del mese di Settembre. Al mattino l'inquinamento è trattenuto sotto costa; nel pomeriggio viene spinto a Ovest parallelamente ad essa (20-9-1972).

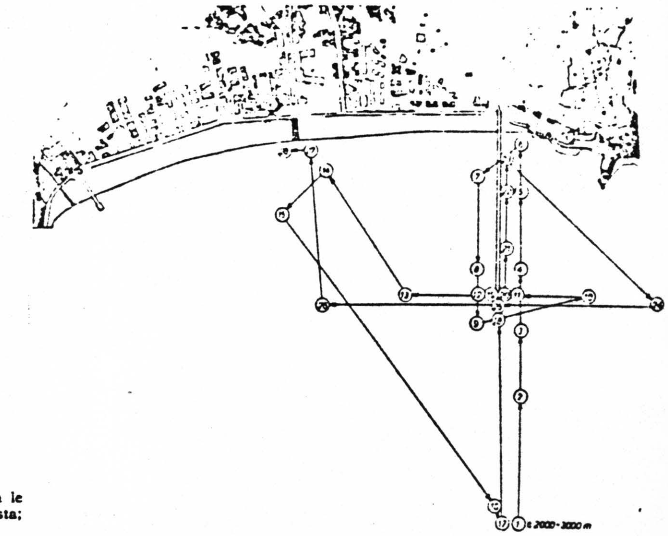


Fig. 9. - Percorso della barca lungo il quale è stato eseguito l'esame chimico in continuo, e numero progressivo dei prelievi di campioni di acqua per l'esame batteriologico, dopo l'entrata in funzione della condotta fecale di 400 m, dotata di diffusore, che scarica al largo il liquame grigliato di Maiori.

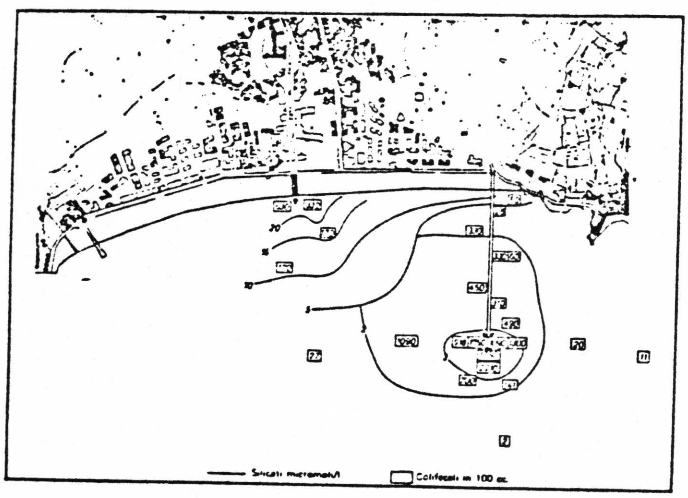


Fig. 10. - Diffusione dell'inquinamento in mare dopo l'entrata in funzione della condotta sottomarina. Notare il numero fortemente ridotto di coli fecali già sopra il diffusore della condotta stessa. Residua ancora un modico inquinamento microbico alla foce del fiume, legato agli scarichi fecali che l'abitato di Tramonti, nell'interno, sversa nelle sue acque (26-10-72 - Mattina).

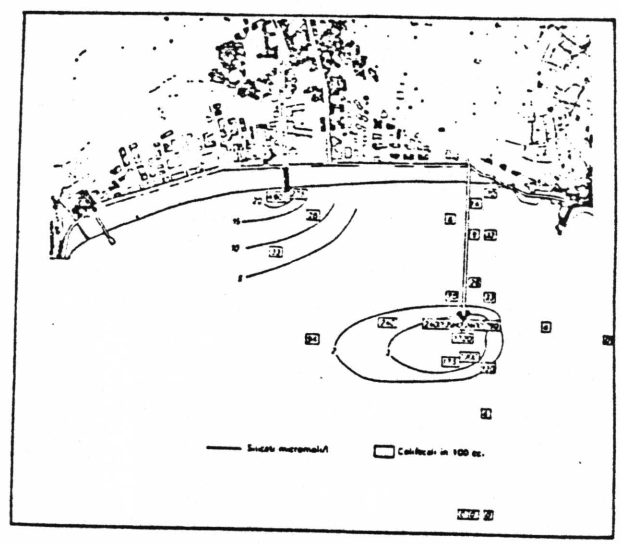


Fig. 11. - L'inquinamento viene spinto parallelamente alla costa. (27-10-72 - pom.).

Figure 25. Distribution of silicates and coliforms at the mouth of the Regenna River (Paoletti, et. al., 1975).

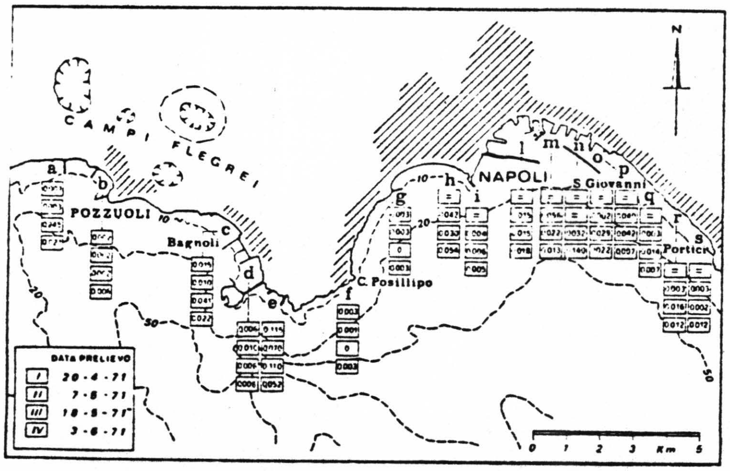


Fig. 2. — Concentrazione dei nitriti nelle stazioni studiate.

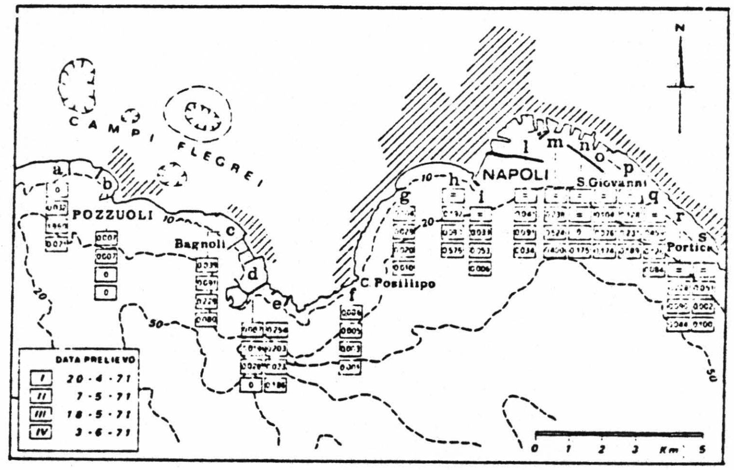


Fig. 3. — Concentrazione dei nitrati nelle stazioni studiate.

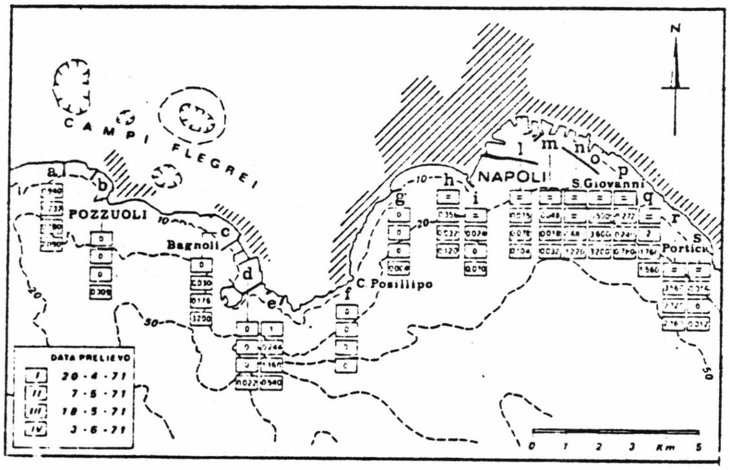


Fig. 4. — Concentrazione dei fosfati nelle stazioni studiate.

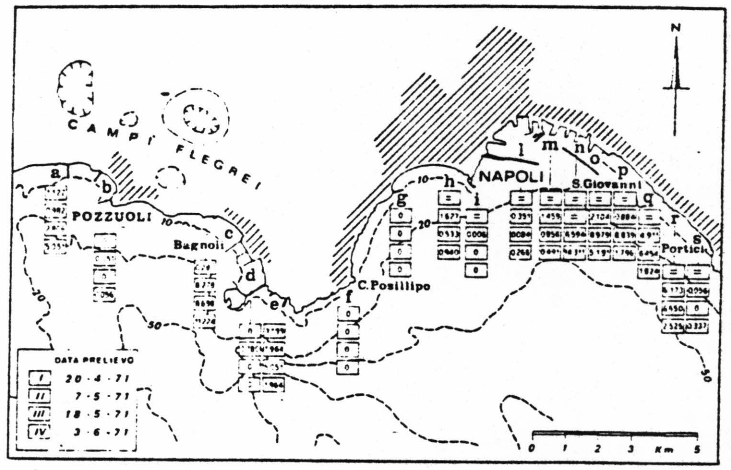


Fig. 5. — Concentrazione dei silicati nelle stazioni studiate.

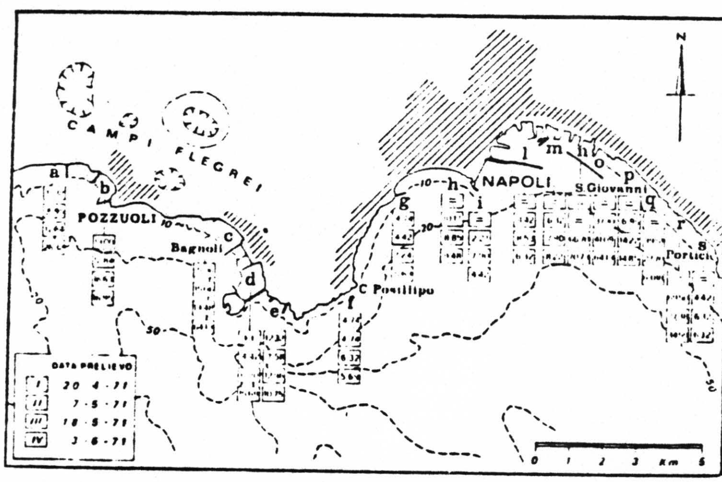


Fig. 6. — Concentrazione delle sostanze organiche nelle stazioni studiate.

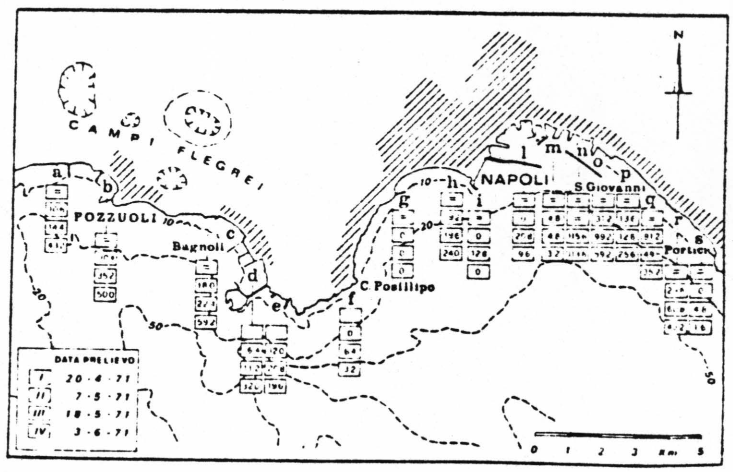


Fig. 7. — Concentrazione del BOD_5 nelle stazioni studiate.

Figure 26. Effect of sewage effluents on several water quality parameters at Naples and Pozzuoli (Carrada et. al., 1974).

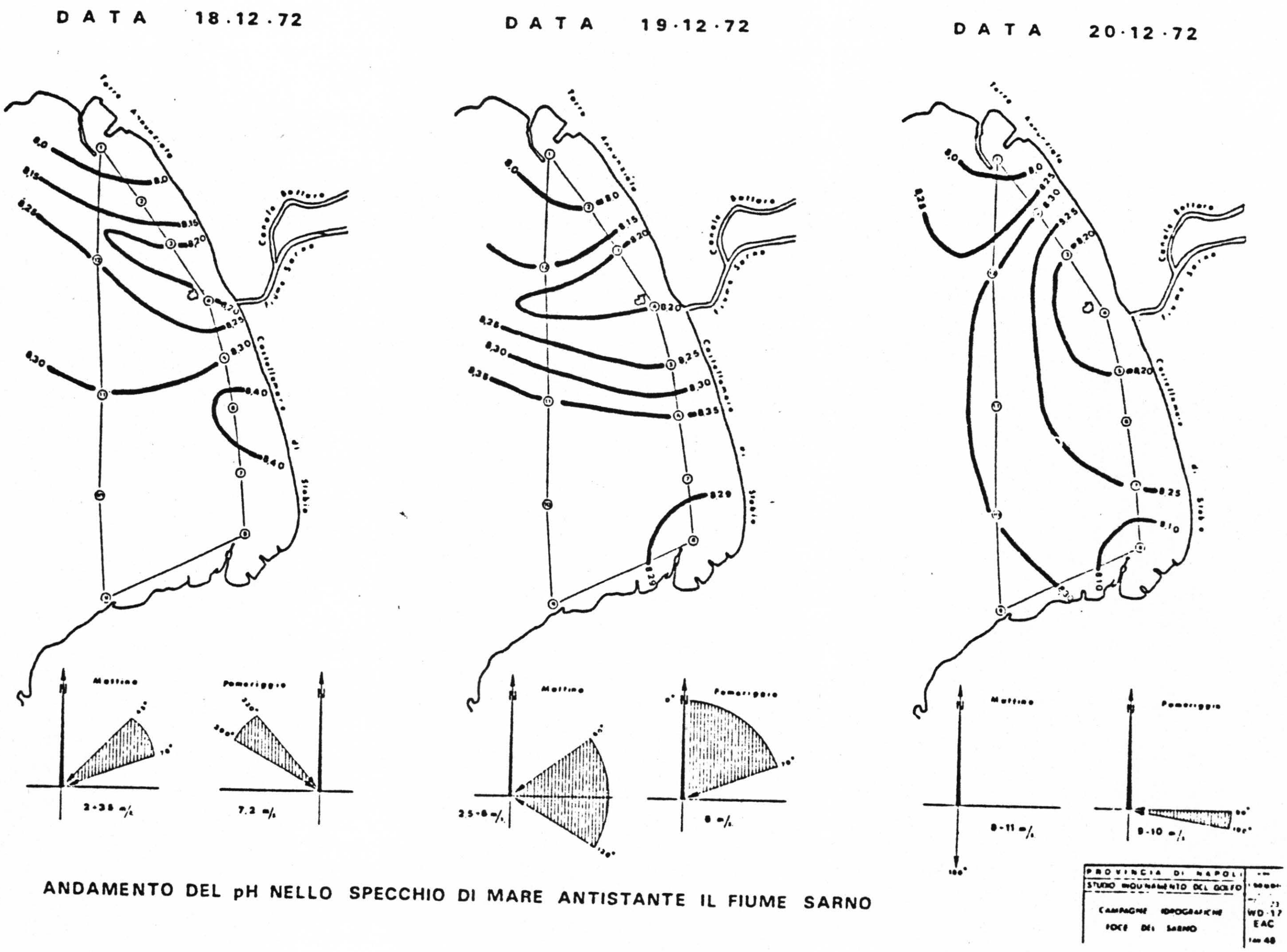
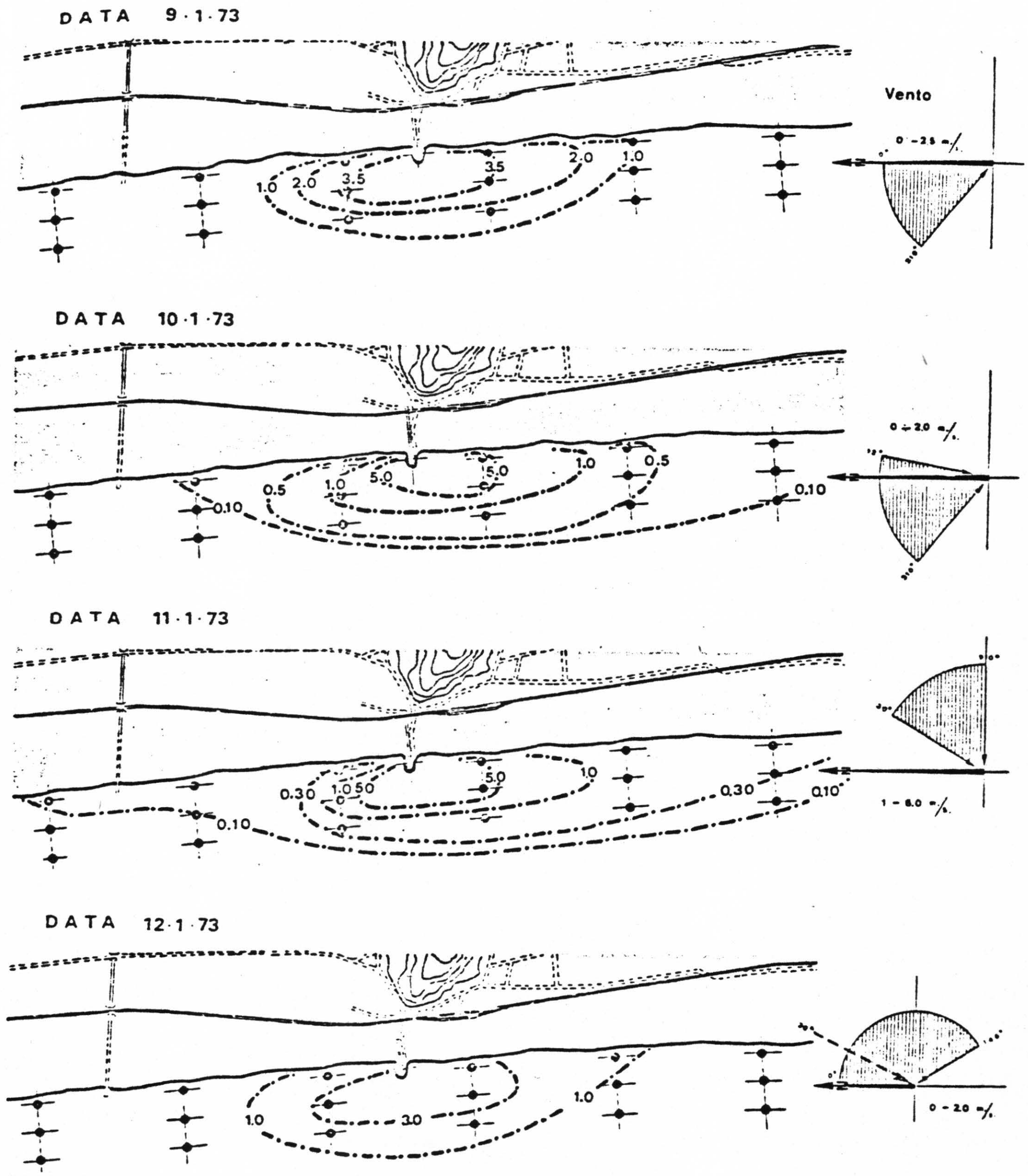


Figure 27. Sewage and wind effects at the river Sarno and at Cuma (Eurostaff Report, vol.I., 1973).



Cuma:
Esempi di andamento dei fosfati –

Figure 27. continued.

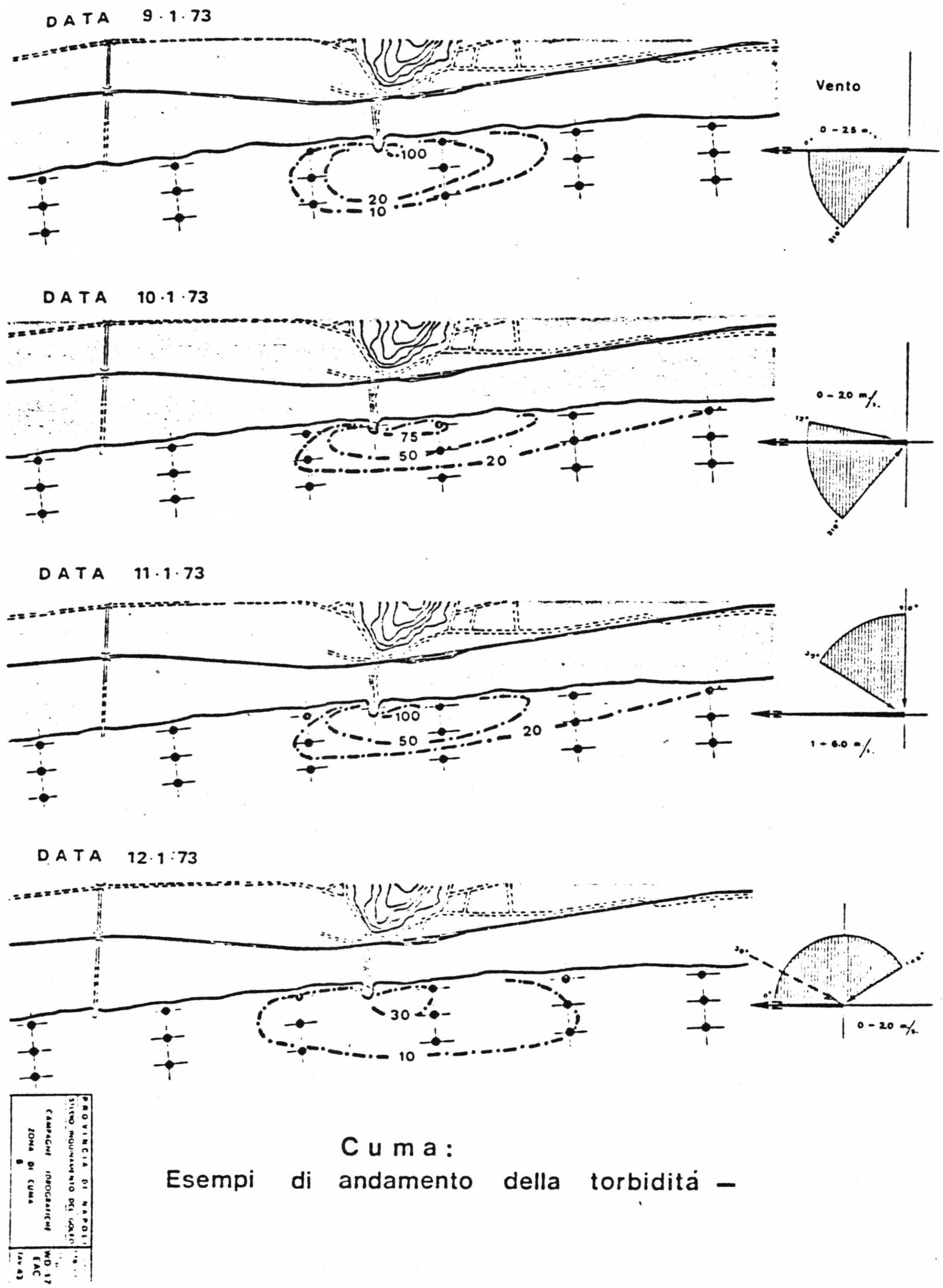


Figure 27. continued.

features, the industrial area is remarkably clear in comparison to other times when the materials remain in the vicinity. Local rainfall will wash these materials from the air and add them to the street runoff.

Most of the industrial wastes are added to either the Harbor of Naples or the area north of Monti di Procida. Both areas are highly polluted. The latter area was previously a favorite swimming spot before the industries were built.

Table 8, taken from Eurostaff Report indicates the BOD pollution for three areas entering the Sarno River. Tables 9 and 10 taken from Insola _et al_. (1973) and the Eurostaff Report show a summary of pollutants in effluents from industries of the area.

Before one can assess the effects of industrial contaminants, it would be necessary to determine the amounts and types of air pollution per day for each industry and to determine the amount of effluent and amounts of contaminants in the effluents. These data can be used to determine the loading effect on the sewage and adjacent waters where the material is being disposed.

IX. Hydrocarbons

No data on hydrocarbon concentration of the Bay of Naples waters were found during the preliminary review of the literature. Some information is available on the concentrations of hydrocarbons in industrial effluents and could be related to volumes of water used if these data are available. Table 11, taken from Insola, Romano and Caprio (1973), indicates the various pollutants, including hydrocarbons, related to industrial wastes. Normally,

Table 8. Industrial BOD loadings in the Sarno River from Naples, Salerno, and Avellino (Eurostaff Report, vol. II, 1973).

COMPONENTE	Carico inquinante in t/g B.O.D.$_5$		
	NAPOLI	SALERNO	AVELLINO
A) Domestica	2.050	12.500	1.180
B) Industriale			
- Concerie	2.000	1.300	72.800
- Alimentare	0,976	14.374	0,366
- Meccanica	0,004	0,049	----
- Chimica	2.843	0,123	----
- Varie	1.211	17.225	----
Totale	9.084	45.571	74.346
Tot. Generale	129.001		

Table 9. Pollutants in industrial effluents (Insola et al., 1973).

TABELLA 3

Concentrazioni di inquinanti in effluenti acquosi da alcune unità di processo.

Tipo di unità	Desalinizzazione	Distillazione atmosferica (*)	Distillazione sotto vuoto	Cracking termico e catalitico	Neutraliz. soluzioni caust. fenol. spente
pH	7-9	4-7	6-7	—	—
Ammoniaca, ppm	2	10-70	—	80-7000	—
Oli, ppm	20-500	7-10	—	30-100	—
Fenoli, ppm	10-20	5-15	10-30	55-1400	5000-10000
Solfuri, ppm	1-10	15-40	10-30	40-9000	3000
Acqua alimentata, Kg/tonn. carica	30-100	50	50-250 (stripp.) 50-250 (eiettori)	50-200	—

(*) I dati si riferiscono ad un'unica raffineria italiana.

Table 10. Industrial pollutants entering the Gulf of Naples at sources shown in Figures 22-26 (Eurostaff Report, vol. II, appendix, 1973).

Tabella n. 14 - VALORI MEDI ANALISI SCARICHI EFFLUENTI INDUSTRIALI - Cfr. Tavole 22-26 -

Determinazione	Scarico Numero:											
	F 1b	10a	26	27	28	29	29a	29b	29d	30	120	12[illegible]
B.O.D.5	78	44	222	109	107	40	96	38	41	230	373	177
C.O.D.	286	181	303	410	353	157	340	160	166	606	633	333
pH	6.9	7.1	7.3	7.60	7.9	7.8	7.5	8.05	7.43	7.35	7.39	7.[illegible]
Solidi totali	7741	28833	1013	613	1223	1480	1843	1521	2151	1010	4365	2389
Stabilità	<5	5	1	> 1	5	5	1	5	< 5	1	1	2
Ammoniaca	28.2	0.9	60.0	35.7	4.12	14.1	12.7	12.2	9.3	12.[illegible]	38.3	7.5
Nitriti	-	-	-	-	-	-	-	-	-	-	-	-
Nitrati	73	9.4	62.2	27.7	59.5	12.7	29.8	19.3	26.1	68	12.0	9.7
Fosfati	2.4	2.8	11.7	10.5	0.9	4.2	4.5	2.40	2.30	5.4	5.34	3.22
Cromo totale	-	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.
Ferro	1.40	3.5	2.13	1.2	4.16	1.80	3.04	1.73	4.66	2.33	4.1	5.4
Manganese	-	0.03	ass.	ass.	0.08	ass.	0.05	0.03	0.12	ass.	0.73	0.[illegible]
Zinco	0.06	0.06	0.03	0.36	0.18	0.08	0.12	0.04	0.05	ass.	2,40	1.8[illegible]
Rame	37.7	0.21	0.17	0.06	0.08	ass.	0.05	0.05	ass.	0.06	0.53	0.0[illegible]
Piombo	-	-	-	-	-	-	ass.	-	-	-	-	-
Silice	-	-	-	-	-	-	ass.	-	-	-	-	-
Cianuri	-	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.
Fenoli	0.07	0.11	0.24	0.17	0.08	0.09	0.23	0.11	0.1[illegible]	0.06	0.06	0.07
Estr.Con. Solv.	20	66	6.66	5.0	5.0	9.0	-	2.6	9.0	2.0	6.2	120.2
Cloro libero	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.
Solfuri	-	-	-	-	-	-	-	-	-	0.3	0.29	0.47
Detergenti (ABS)	-	-	-	-	-	-	-	-	-	0.7	0.71	0.1[illegible]
nota : risultati in mg/l escluso pH e stabilità												

Table 10. continued.

Determinazione	Scarico numero:											
	[illegible]	12[illegible]	12[illegible]	1[illegible]	1[illegible]	[illegible]A	[illegible]	[illegible]	14[illegible]	14[illegible]	1[illegible]	170
B.O.D.5	64	197	80	136	3[illegible]0	513	238	100	424	[illegible]89	669	285
C.O.D.	[illegible]06	473	160	405	[illegible]86	1920	546	[illegible]60	880	850	963	1616
pH	7.95	7.[illegible]	7.1	7.78	[illegible].21	7.73	7.68	10	8.03	4.6	7.55	9.66
Solidi totali	[illegible]4956	1926[illegible]	2424	4402	1850	[illegible]069	1290	20078	[illegible]468	13192	2760	[illegible]568
Stabilità	<5	3	>1	<5	>1	<1	1	<5	1	<5	1	5
Ammoniaca	0.8[illegible]	5.[illegible]	15	0.69	12.66	59.[illegible]	43.5	1.61	50.3	3.12	[illegible]4.74	17.3
Nitriti	-	-	-	-	-	-	-	-	-	-	-	-
Nitrati	[illegible]	10.4	[illegible]0	7.69	35.[illegible]	28[illegible]	19.7	3.4[illegible]	38	-	[illegible]0.6	18[illegible]
Fosfati	0.18	2.4	5.0	0.15	6.02	4.68	4.73	0.[illegible]	[illegible]0.2	4.25	7.86	20.4
Cromo totale	ass.	0.04	ass.	ass.	0.11	ass.	ass.	ass.	0.07	0.93	0.09	ass.
Ferro	0.2[illegible]	1.55	3.0	[illegible].90	2.2[illegible]	[illegible].26	1.55	0.9[illegible]	1.64	8.40	[illegible].21	0.56
Manganese	ass.	ass.	ass.	ass.	ass.	ass.	ass.	0.20	ass.	0.35	ass.	ass.
Zinco	0.1[illegible]	0.53	-	0.12	0.1[illegible]	0.15	0.1[illegible]	0.0[illegible]	0.16	-	0.1[illegible]	-
Rame	0.01	0.07	ass.	0.09	0.27	0.3[illegible]	0.0[illegible]	ass.	0.07	5.1[illegible]	0.12	-
Piombo	-	-	-	-	-	-	-	-	-	-	-	-
Silice	-	-	-	-	-	-	-	-	ass.	-	-	-
Cianuri	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	0.02	ass.	ass.	ass.
Fenoli	0.07	0.04	0.05	0.10	0.0[illegible]	0.[illegible]	0.07	0.08	0.03	0.01	0.0[illegible]	ass.
Estr.Con.Solv.	ass.	2.00	ass.	ass.	[illegible]	205	4.00	3.3	8.6	3.0	6.00	ass.
Cloro libero	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	0.6	ass.	ass.	ass.
Solfuri	0.16	0.07	[illegible].70	ass.	0.89	ass.	0.44	0.70	0.41	0.38	0.0[illegible]	1.4
Detergenti	0.1[illegible]	0.30	0.[illegible]	0.3[illegible]	[illegible].24	0.[illegible]0	[illegible].83	0.06	[illegible].8	0.13	1.0[illegible]	0.01

Determinazione	Scarico numero:											
	171	172	173	206	219	220	221	223	22[illegible]	[illegible]8	229	23[illegible]
B.O.D.5	155	525	317	61	82	73	127	62	10	11	30	26
C.O.D.	550	3175	1225	110	441	416	500	333	25	25	70	100
pH	8.2[illegible]	8.27	7.52	7.57	6.73	7.55	7.25	8.20	7.67	7.3[illegible]	7.62	7.56
Solidi Totali	1468	13552	1784	885	1820	1551	1530	576	225	256	909	780
Stabilità	5	<5	>1	<5	<5	<5	<5	<5	>5	>5	>5	>5
Ammoniaca	18.9	27.3	43.7	4.7	0.99	0.60	0.77	0.61	0.06	1.08	0.21	0.23
Nitriti	-	-	-	-	-	-	-	-	-	-	-	-
Nitrati	111.5	209	82	6.23	214	76.[illegible]	47.6	22.3	3.51	3.8	61.0	67.7
Fosfati	2.4	1.5[illegible]	9.5	5.2	0.64	0.35	0.20	1.44	0.09	0.75	0.80	0.08
Cromo totale	ass.	1.2[illegible]	0.04	-	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.
Ferro	0.32	5.3	0.30	0.8	13.9	0.54	18.1	1.65	1.00	0.40	5.28	15.4
Manganese	-	-	-	-	ass.	ass.	ass.	ass.	-	-	-	-
Zinco	-	-	-	-	-	-	-	-	-	-	-	-
Rame	-	-	-	-	-	-	-	-	-	-	-	-
Piombo	-	-	-	-	-	-	-	-	-	-	-	-
Silice	-	-	-	-	-	-	-	-	-	-	-	-
Cianuri	ass.	ass.	ass.	-	ass.	ass.	-	ass.	ass.	ass.	ass.	ass.
Fenoli	ass.	ass.	ass.	-	ass.	-	-	-	ass.	ass.	ass.	ass.
Estr.Con.Solv.	ass.	22.0	ass.	-	4.0	ass.	20.0	ass.	-	-	-	-
Cloro libero	ass.	ass.	ass.	ass.	ass.	ass.	ass.	ass.	-	-	-	-
Solfuri	0.06	5.55	1.05	-	ass.	0.01	0.03	0.33	ass.	ass.	ass.	ass.
Detergenti	0.15	0.05	0.62	-	0.04	0.03	0.03	0.01	-	-	-	-

Table 10. continued.

Determinazione	Scarico numero:										
	231	232	235a	236	237	248	251	252	253	254	
B.O.D.5	35	278	94	155	194	4	21	49	17	10	
C.O.D.	100	450	250	640	410	53	183	223	42	72	
p H	6.9	7.35	7.63	7.68	7.4	6.5	6.77	6.91	6.43	6.38	
Solidi totali	218	1192	1244	840	596	1170	30606	25962	2162	17789	
Stabilità	5	> 1	5.0	> 5	5	> 5	4	2	> 5	> 5	
Ammoniaca	4.82	14.6	0.07	4.43	4.12	1.71	1.88	3.17	2.52	1.10	
Nitriti	-	-	11.80	-	-	-	-	-	-	-	-
Nitrati	150	-	0.12	16.7	9.00	7.27	7.68	5.6	4.66	6.3	
Fosfati	0.37	-	ass.	0.03	0.13	0.71	1.18	3.82	2.0	0.44	
Cromo totale	ass.	-	0.45	ass.	ass.	-	-	-	-	-	
Ferro	2.30	1.10	-	1.71	0.31	0.38	0.25	0.45	1.75	0.30	
Manganese	-	-	-	-	-	-	-	-	-	-	
Zinco	-	-	-	-	-	-	-	-	-	-	
Rame	-	-	-	-	-	-	-	-	-	-	
Piombo	-	-	-	-	-	-	-	-	-	-	
Silice	-	-	-	-	-	-	-	-	-	-	
Cianuri	ass.	ass.	ass.	ass.	ass.	-	-	-	-	-	
Fenoli	-	-	-	ass.	ass.	-	-	-	-	-	
Estr. Con. Solv.	-	-	-	-	-	-	-	-	-	-	
Cloro Libero	-	-	-	-	-	ass.	ass.	ass.	ass.	ass.	
Solfuri	ass.	-	ass.	ass.	ass.	-	-	-	-	-	
Detergenti	-	-	-	-	-	-	-	-	-	-	

Bacino (N°)	Estensione costiera (km.)	Carico inquinante	
		B.O.D.$_5$(Kg./g.)	tossici
0	5,75	18.494	apprezzabili
F	0,25	37	sensibili
10	1,20	65,5	notevoli
11	3,40	7,6	presenti
12	8,40	12.584,6	notevoli
14	3,20	166.894	apprezzabili
15	1,95	50.371	presenti
16	0,45	22.307	"
19	1,20	14.325	"
28	5,00	2.608	"
29	1,40	1.788	"
29A	0,50	113.270	"
31	2,00	9,0	"
		402.960	

Table 11. Hydrocarbons in refinery effluents (Insola et al., 1973).

TABELLA 2

Concentrazioni di inquinanti in effluenti acquosi da unità di cracking.

Fase idrocarburica		Fase acquosa			
Fonte	Inter. d'eboll. (°F)	Fenoli (p.p.m.)	Solfuri (p.p.m.)	Oli (p.p.m.)	Ammoniaca (p.p.m.)
Benzina FCC	100-430	300-600	3000	—	2200
Benzina FCC	—	55	—	30	—
Benzina FCC	—	70-260	40-305	—	85-440
Benzina FCC e di topping	—	200-300	1000-5000	—	1000-2000
Benzina di cracking	—	700-1400	6000-9000	—	4740-7000
Benzina di cracking catalitico	—	340	1640	—	—
Benzina TCC	100-422	600	2960	—	—
Benzina di cracking catalitico	—	600	—	—	—
Benzina di cracking catalitico	—	290	1500	—	—
Benzina FCC	C_5-390	300	1000	100	—
Benzina FCC	—	550	3200	—	2500
Benzina FCC	—	—	—	30	—
Benzina di cracking catalitico	100-392	235	1300	—	—

TABELLA 3

Concentrazioni di inquinanti in effluenti acquosi da alcune unità di processo.

Tipo di unità	Desalinizzazione	Distillazione atmosferica (*)	Distillazione sotto vuoto	Cracking termico e catalitico	Neutraliz. soluzioni caust. fenol. spente
pH	7-9	4-7	6-7	—	—
Ammoniaca, ppm	2	10-70	—	80-7000	—
Oli, ppm	20-500	7-10	—	30-100	—
Fenoli, ppm	10-20	5-15	10-30	55-1400	5000-10000
Solfuri, ppm	1-10	15-40	10-30	40-9000	3000
Acqua alimentata, Kg/tonn. carica	30-100	50	50-250 (stripp.) 50-250 (eiettori)	50-200	—

(*) I dati si riferiscono ad un'unica raffineria italiana.

values of hydrocarbons in excess of 50 ppm in effluents are considered possible pollutants. The amounts of hydrocarbons indicated in the tables as being introduced into the beach waters via the sewage could provide a negative impact. As much of the refining capacity is adjacent to the harbor, most of the hydrocarbons will undoubtedly be added to the harbor waters through the 6 sewage disposal inlets (Fig. 31).

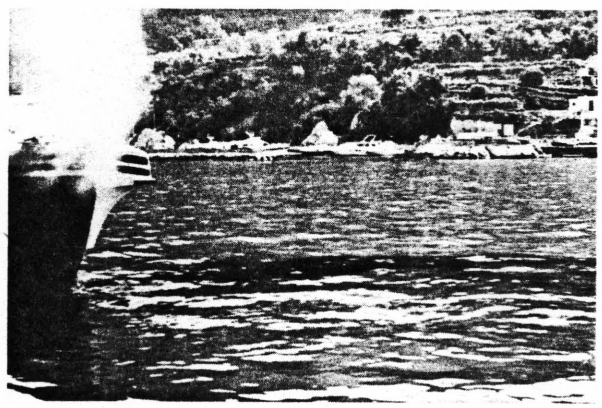
One source of major concern is the hydrocarbons found in the harbor waters. The photographs in Figure 28 illustrate the amounts of oil on the surface of the water. The area devoted to oil shipping was noticeably contaminated. The bottom sediments, as shown in Figure 28, were so enriched with hydrocarbons that the sediment could be burned as a fuel. The surface of the water was covered with methane bubbles, indicating microbial action. The area was anaerobic, as evidenced by the hydrogen sulfide odor associated with the oily sediments.

Oil was present on most waterline surfaces of piers, bulkheads, vessels, etc. in the harbor. There was a distinct gradient, however, that could be detected as a function of distance from the oil docks. The oil in the inner harbor was more abundant than that found in the outer harbor. It is obvious that the oil was being spilled during loading operations. However other oil was being added from the bilges and from the sewage outfalls. In photograph of Figure 31, one can see the obvious oil adjacent to the sewage outfall.

Some information has been recently published for hydrocarbons in the Mediterranean. Figure 29 shows the relative abundance of

1

2



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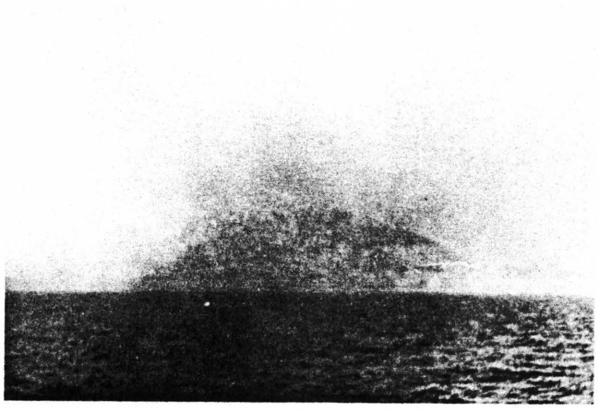

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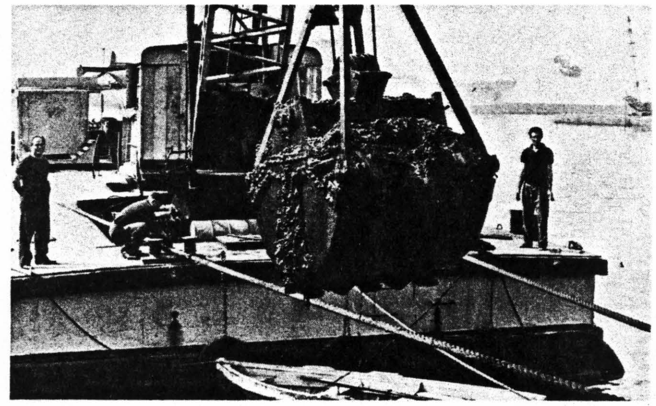

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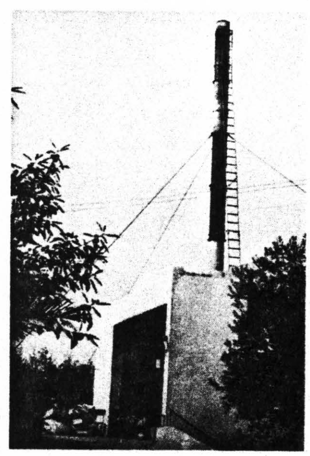

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Figure 28.

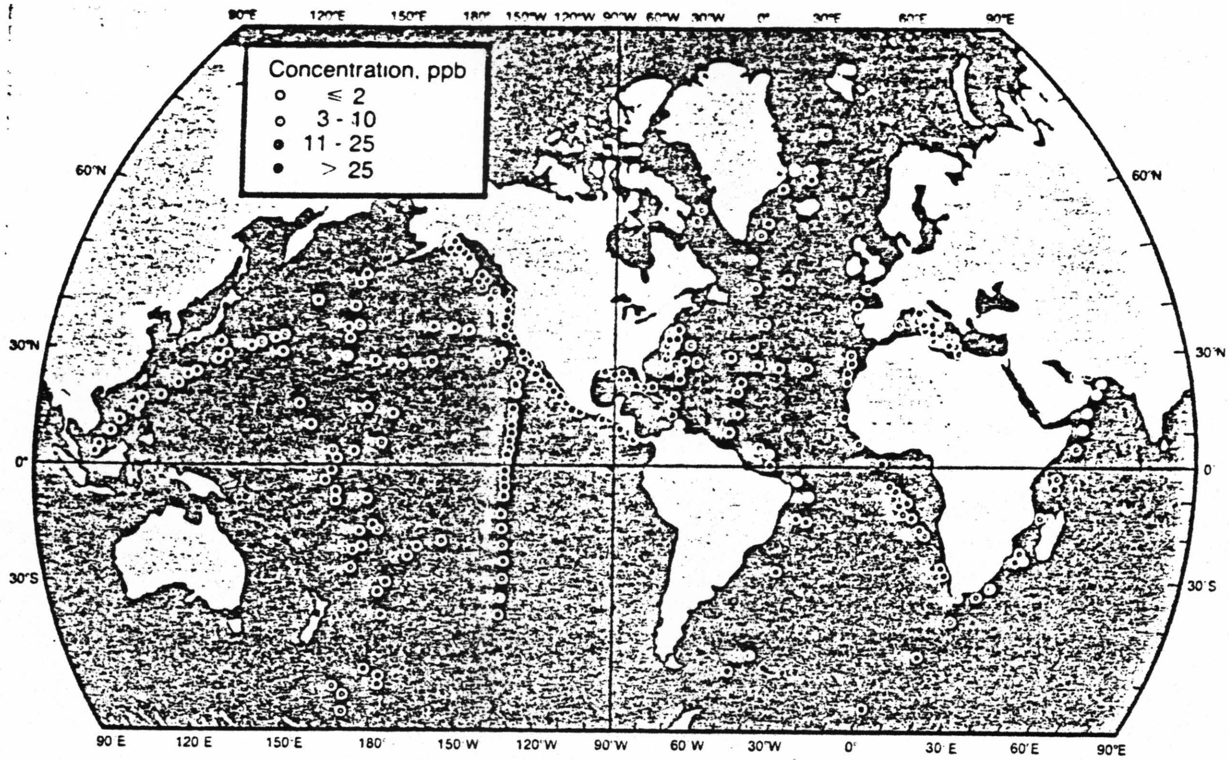


Figure 8. Non-Volatile Hydrocarbons in Surface Waters.

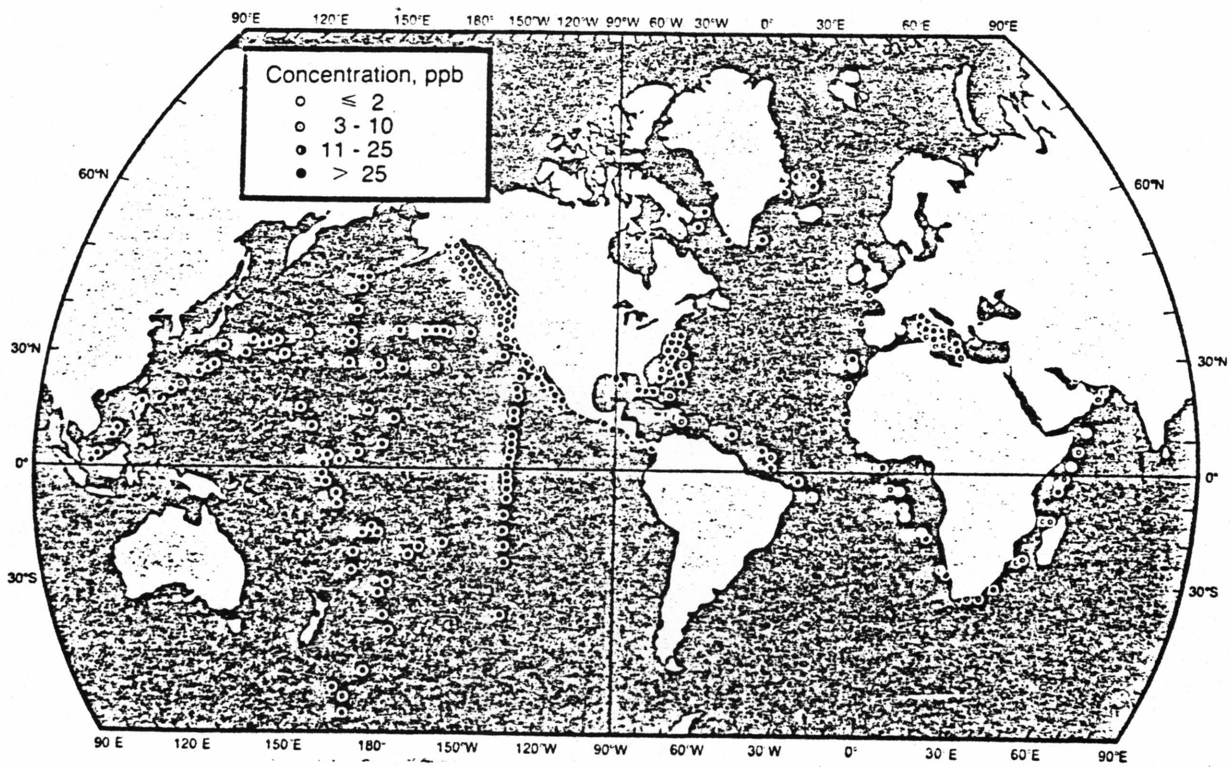


Figure 9. Non-Volatile Hydrocarbons in Subsurface Waters.

Figure 29. Hydrocarbons in the world's oceans (Meyers and Gunderson, 1976).

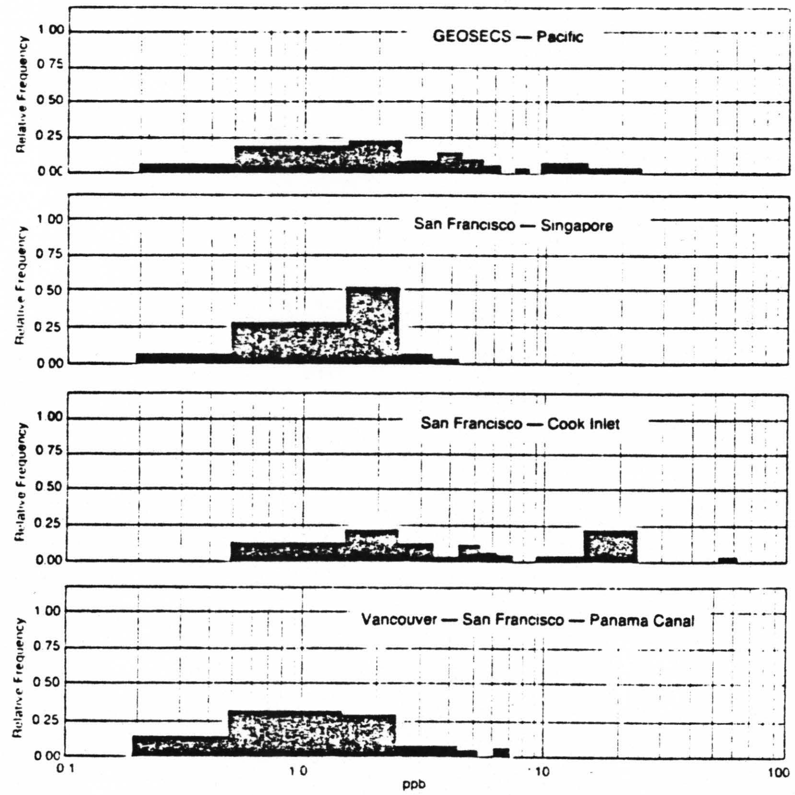


Figure 12a. Frequency Histograms of Non-Volatile Hydrocarbon Measurements in Surface Waters.

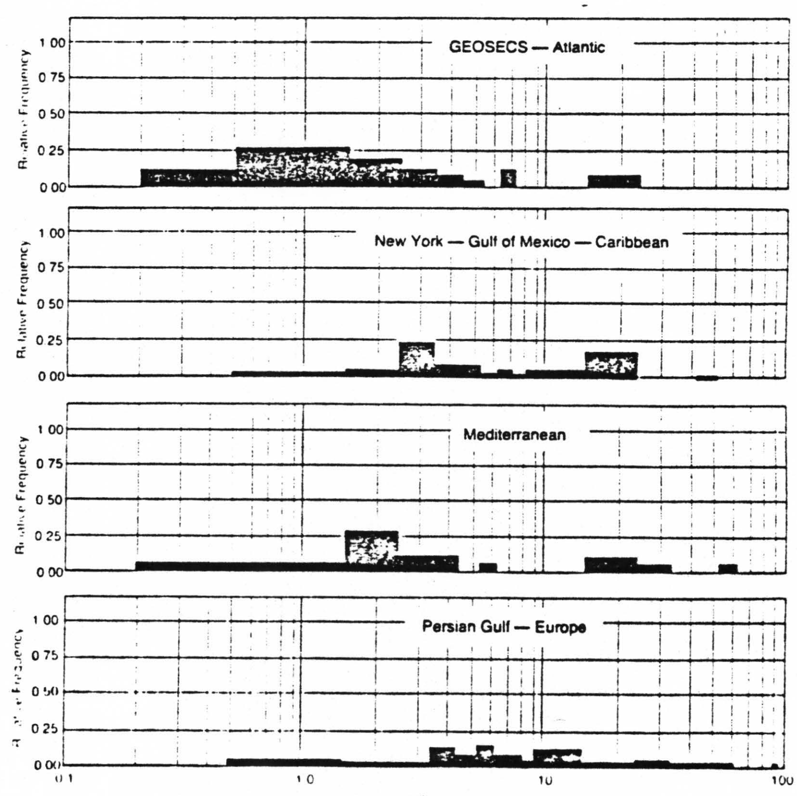


Figure 12b. Frequency Histograms of Non-Volatile Hydrocarbon Measurements in Surface Waters. (Continued.)

Figure 29. continued.

hydrocarbons and sampling sites in various parts of the world. As the Figures indicate, the Mediterranean, in spite of its enclosed geography, major shipping, and other oil related activities, is not significantly greater in hydrocarbon concentration than other areas cited. These data may be related to the fishery data which indicates that the concentrations of hydrocarbons have not significantly altered the fishing in the Mediterranean.

VIII. Naples Port and Boating Activities

Naples Harbor

The harbor of Naples, Figure 30, is a major shipping area with an annual metric tonnage of 45 million, of which 9 million tons are hydrocarbons. In addition, 6 sewage outfalls enter its waters with untreated municipal and industrial waste and street runoff. The amounts of sewage added to the Harbor in one year is large. It will carry 10-20 ppm of nitrogen and 10-20 ppm of phosphorous. Figures 31 and 32 show the sewage outfalls of Naples Harbor and other areas, people fishing adjacent to outfalls, picking up trash from the bay waters and the average amount of vessels in an average day.

During the period of our observations the harbor waters were grossly contaminated. However fish seen everywhere except in the oil dock areas. The sewage outfalls introduced both dissolved and particulate materials, the latter remain floating on the surface. Hydrocarbons were present in most parts of the harbor.

The pollution is a public health hazard as the wind action and other activities allows the bay waters to contaminate the

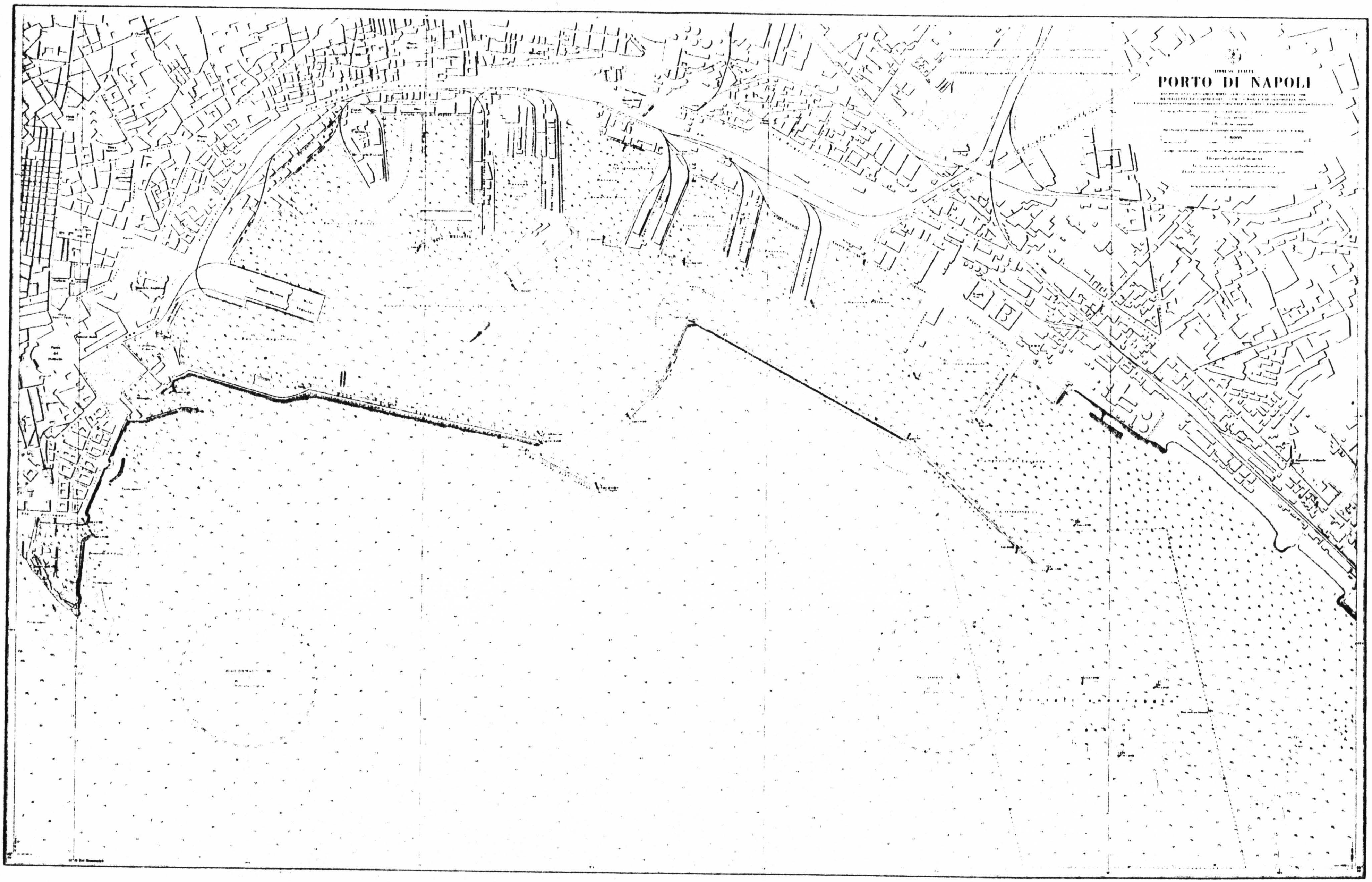
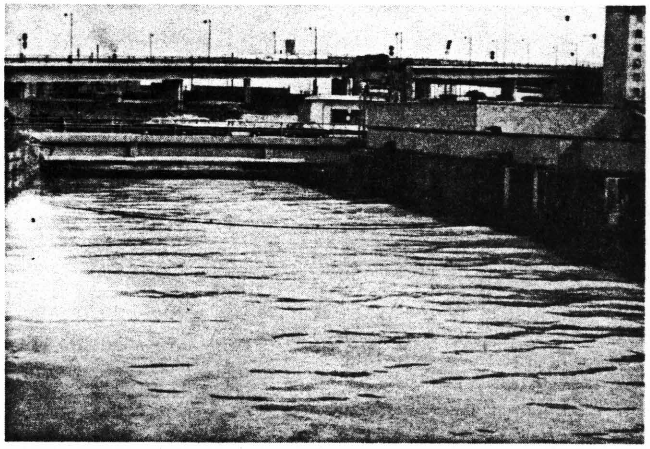


Figure 30.



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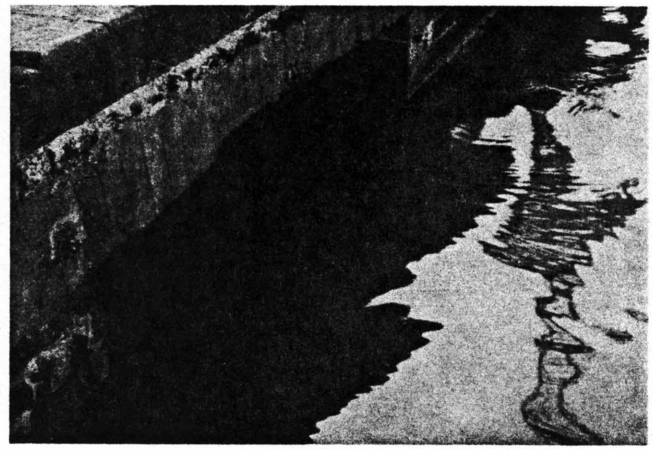

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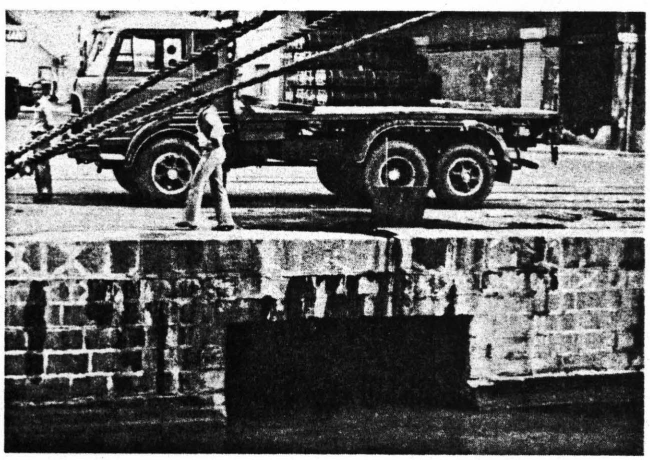

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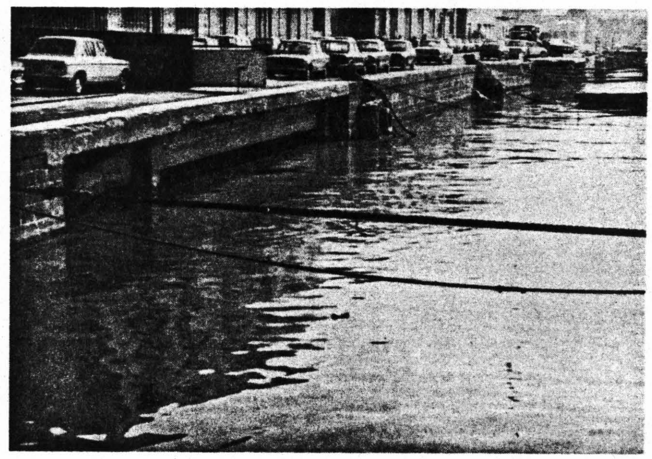

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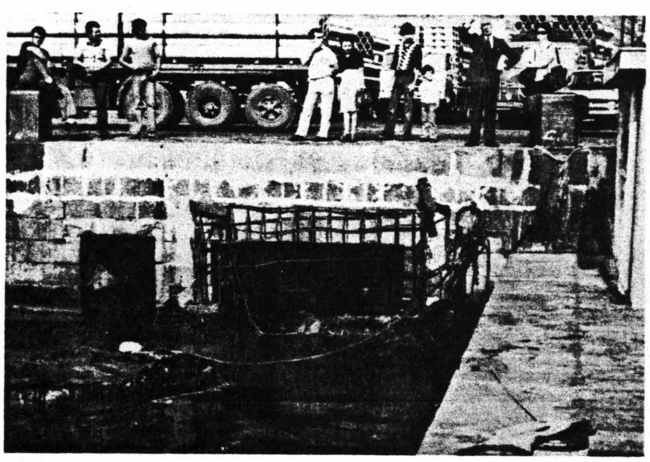

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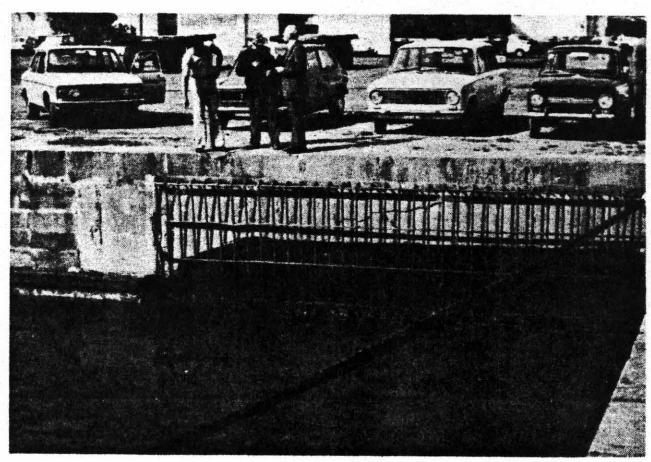

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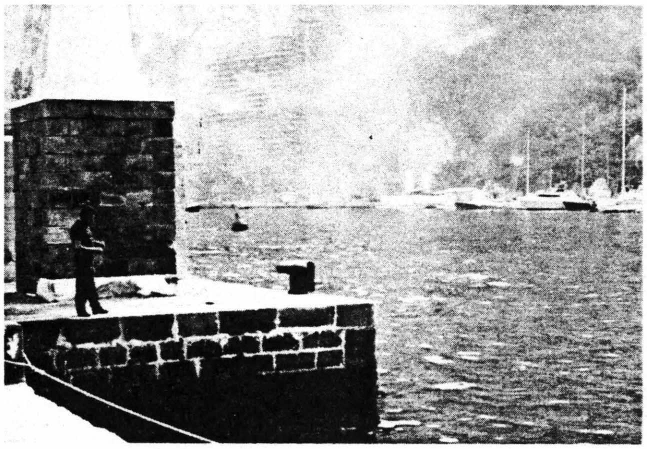
Figure 31.



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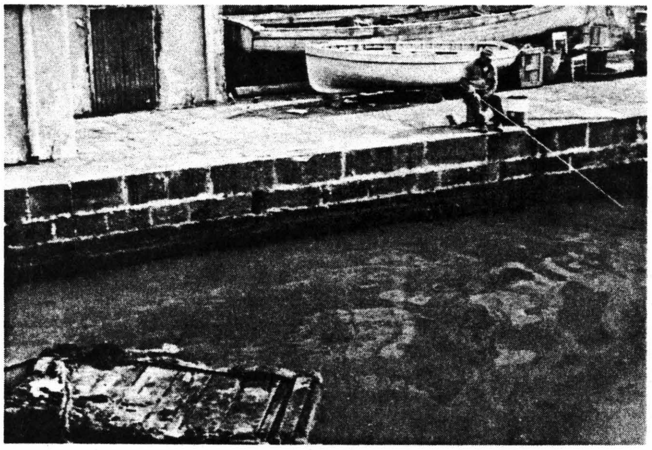

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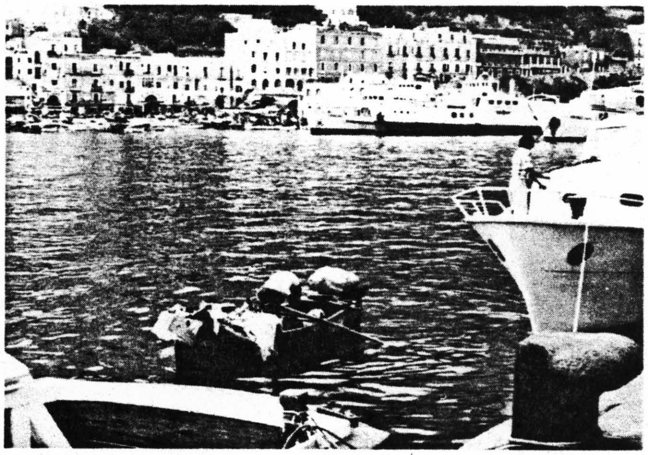

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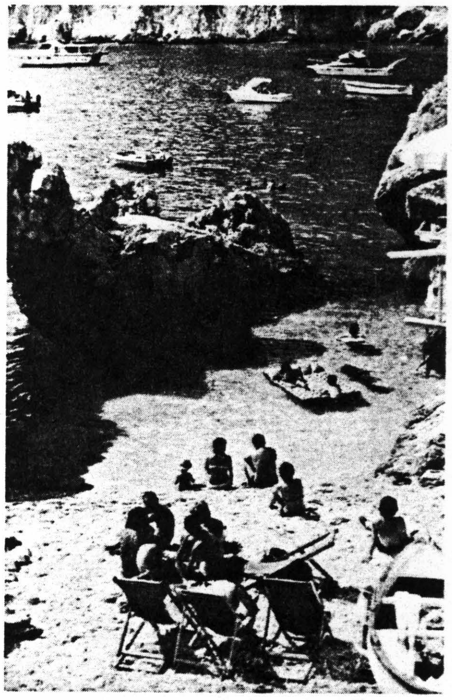

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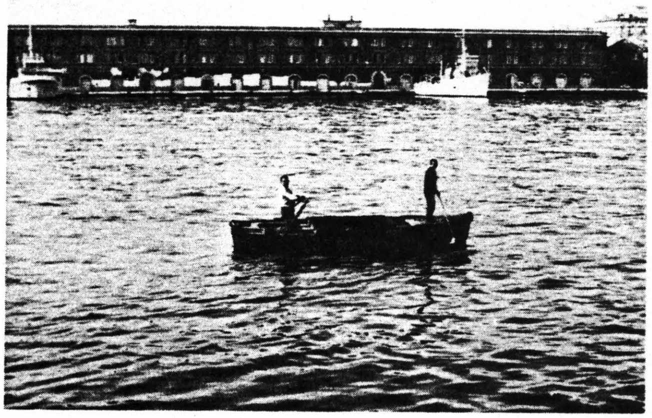

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Figure 32.

wharves and downwind areas. The odors are considerable and may cause allergic reaction in the dock workers, ships company and visitors.

Many parts of the bay indicated anaerobic conditions. This is caused by the high nutrient and BOD loading from the sewage, ships and oil. The poor circulation with the bay, a result of the breakwater configuration, allows the material to concentrate in the harbor waters.

Boating

The number of boats per capita is increasing throughout the world. In Texas there is approximately one boat per family. This increase in boating has required more boat facilities and access to them. This is quite apparent in the Bay of Naples area. Small boats for commercial fishing and recreation are abundant. This activity adds to the pollution load of the environment through the release of hydrocarbons from the bilges, two cycle engines, and spillage during fueling. Sewage from these boats is introduced into the water. Trash left over from eating or other activities is discarded into the water.

The total effects of these activities can be estimated. However time did not permit a good data base to be accumulated. Therefore, it is only possible to indicate the types of pollution that may occur.

X. Fishing

The commercial fishing yield must be considered in a regional evaluation of an environment in the Mediterranean such as the Gulf of Naples. Figure 33 shows the relationships between the

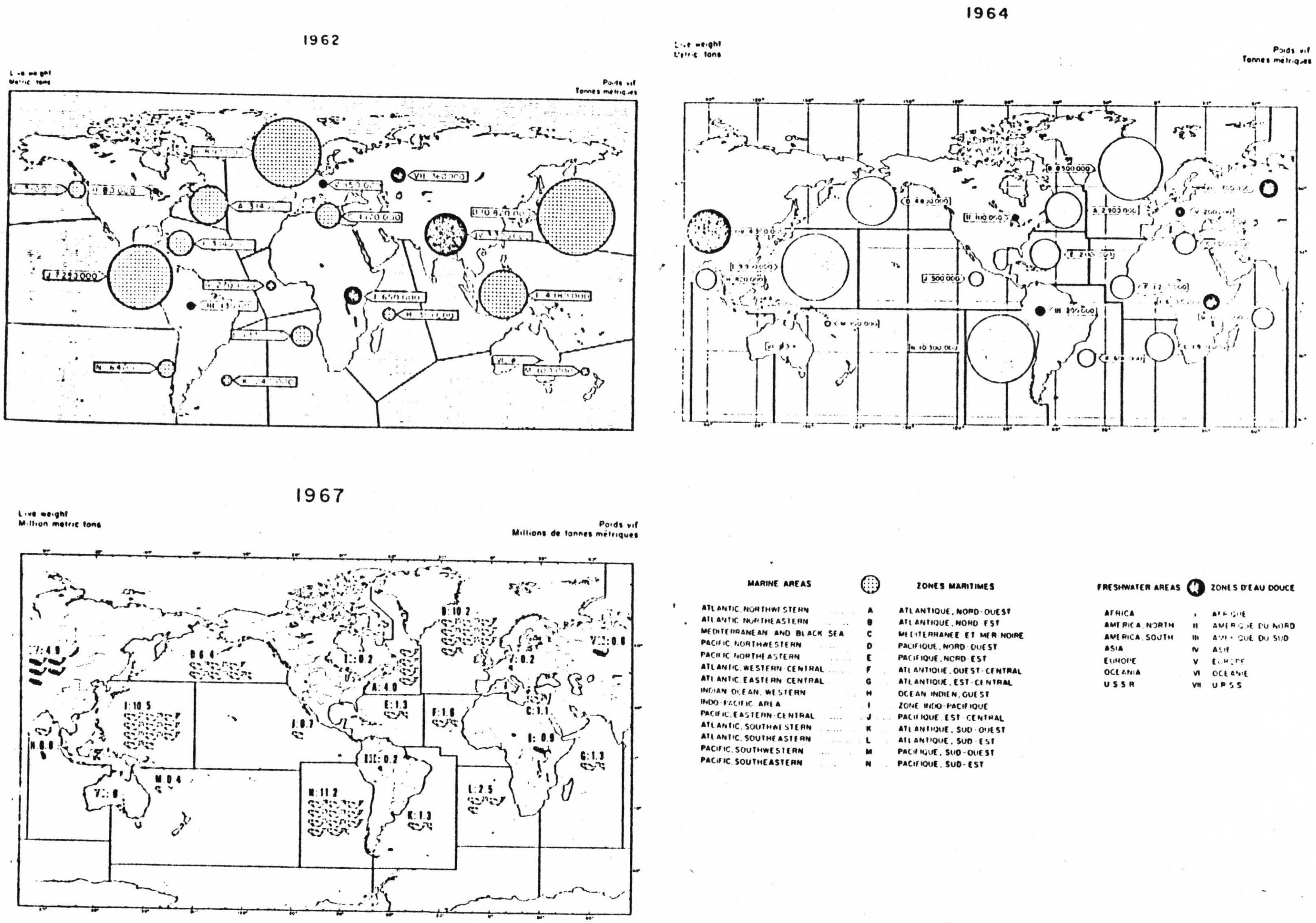


Figure 33. Fish catch statistics of the world (FAO Yearbook of Fisheries, 1938-75).

Mediterranean Black Sea area and other fishing areas of the world. These data, taken from FAO Yearbook of Fisheries Statistics 1938-75, have been summarized over the years for Italy and the Meditterranean Black Sea areas. Table 12 lists the fish catch in these two regions from 1938 to present. No abnormal perturbations can be seen and the fish catch has continually increased through the reported years. The average catch reported for Italy in percent of the Mediterranean Black Sea catch is 34% of the average catch reported for Italy for the last five recorded years. This shows the significance of the Italian fishery in the area and the relative value of the fishery.

The relatively stable fish catch indicates that the area is perhaps at the highest sustaining yield per unit area. If the environment were overfished and the standing stock decreased, a general continuing decline would be noted.

These data also suggest that pollution from coastal areas, such as the Gulf of Naples, has not materially affected the fish yield.

The Eurostaff Report provided graph of fishboat tonnage from 1959 to 1971 (Figure 34). Other data included, Figure 35, shows the catch taken in the Naples area. These figures indicate a continual increased yield of the area. This is remarkable for an active fishery area since the time of the Romans. One would expect that such a continual increase in fish yield indicates that it is in equilibrium with fishing effort. The area of the Gulf of Naples is approximately 960 km^2. If the total fish catch is approximately 7 million kilos, the yield of the bay

Table 12. Fish catch for Italy and the Mediterranean Black Sea areas (FAO Yearbook of Fisheries Statistics, 1938-75).

FISH CATCH FOR ITALY AND THE MEDITERRANEAN BLACK SEA AREA

(TAKEN FROM FAO ANNUAL REPORTS)

Year		Italy	Med and BS
		Metric tens x 10^3	
1938		181.2	700
48		182.8	600
55		257.7	700
56	Total fish	258.9	800
57	catch for	247.7	800
58	Italy	245.7	800
59	All areas.	253.5	800
60		249.5	800
62		271.3	800
63		290.4	900
64		266.3	960
65		277.7	990
66		285.5	1,030
67	Italy	284.3	1,110
68	fish catch	281.0	1,030
69	Med and BS	288.0	940
70	only	320.3	1,070
71		321.1	1,115.5
72		348.7	1,136.7
73		334.2	1,150.5
74		344.1	1,367.0
75		351.9	1,322.5

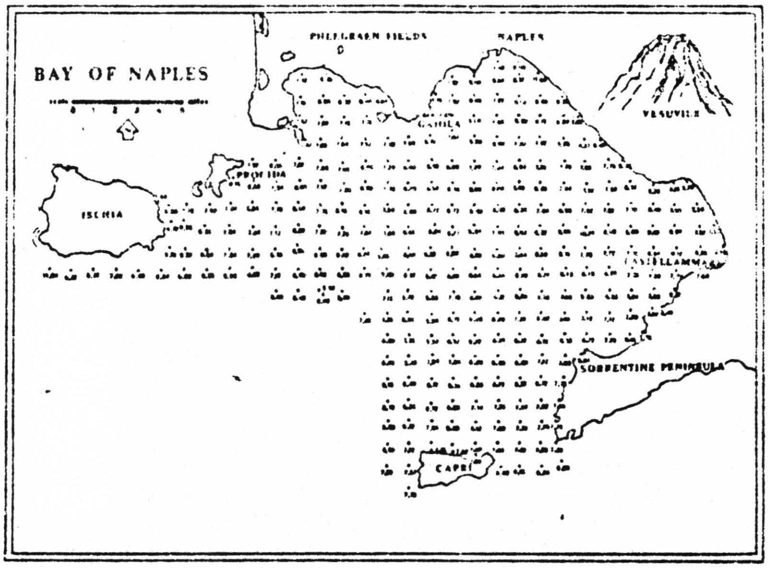


Fig. 6. — Ossigeno disciolto (mg/l) nelle acque di fondo del Golfo di Napoli (Puri, Bonaduce e Malloy, 1964).

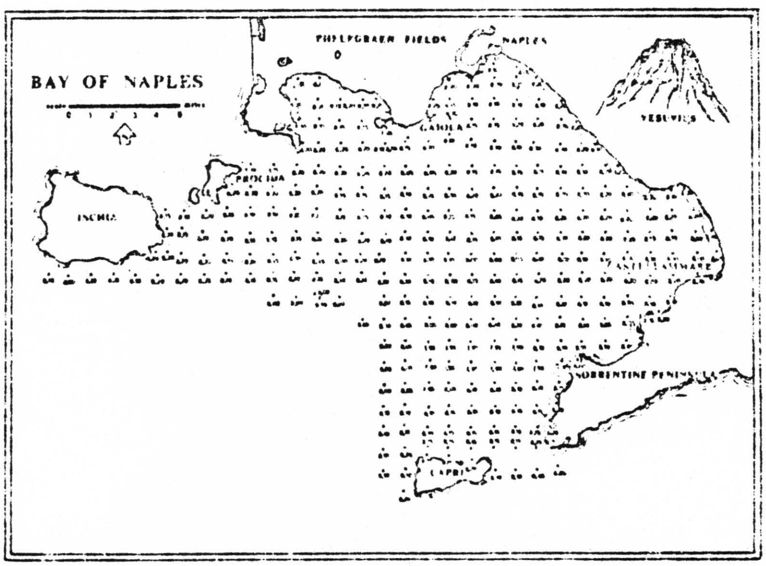
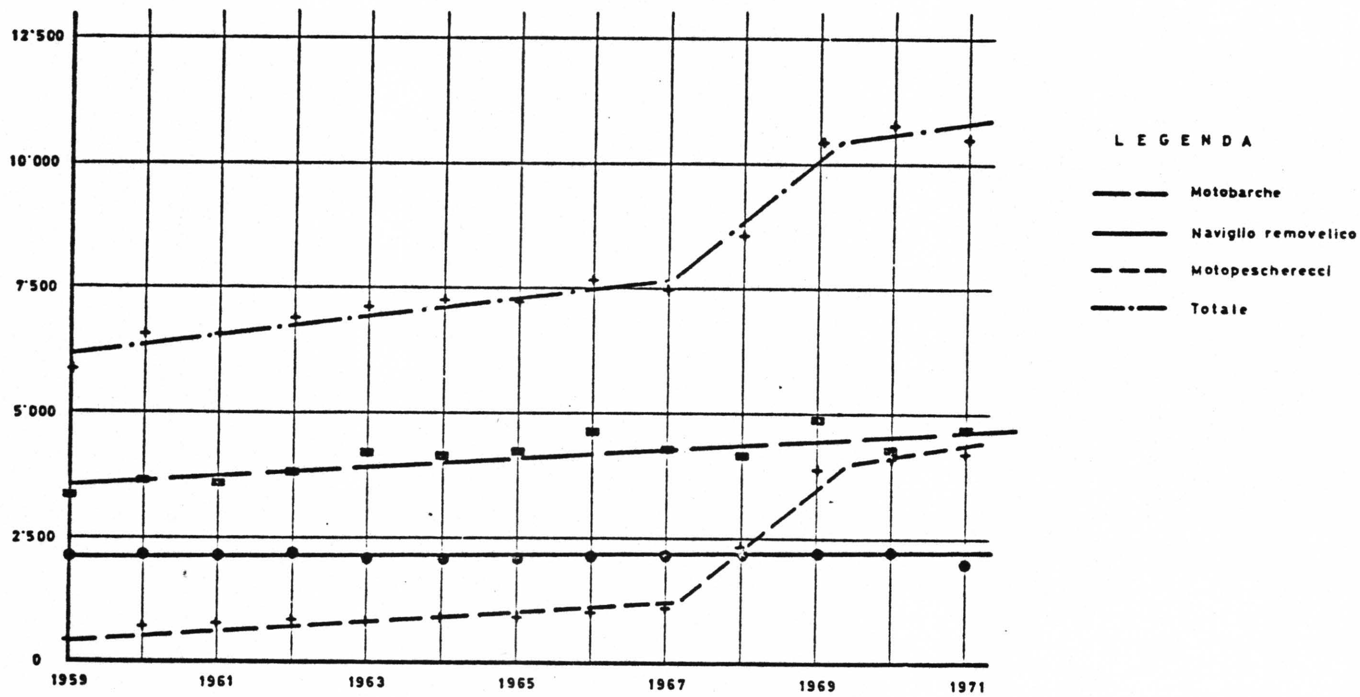


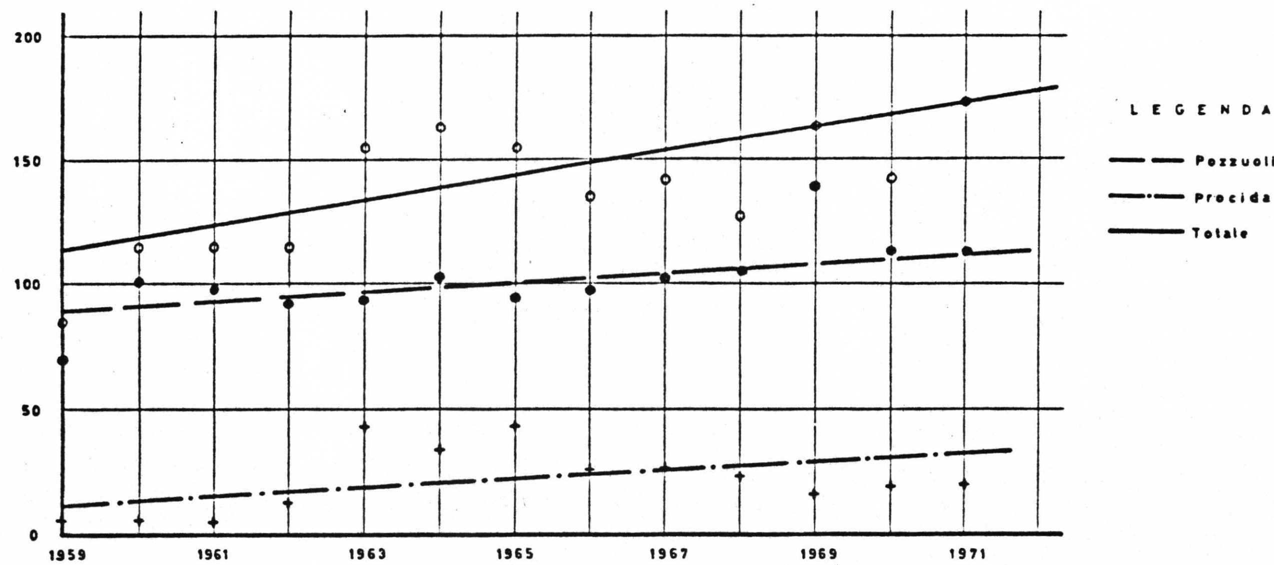
Fig. 7. — pH delle acque di fondo del Golfo di Napoli (Puri, Bonaduce e Malloy, 1964).

Figure 17. Oxygen and pH values in the Gulf of Naples (Carrada and Rigillo-Troncone, 1973).

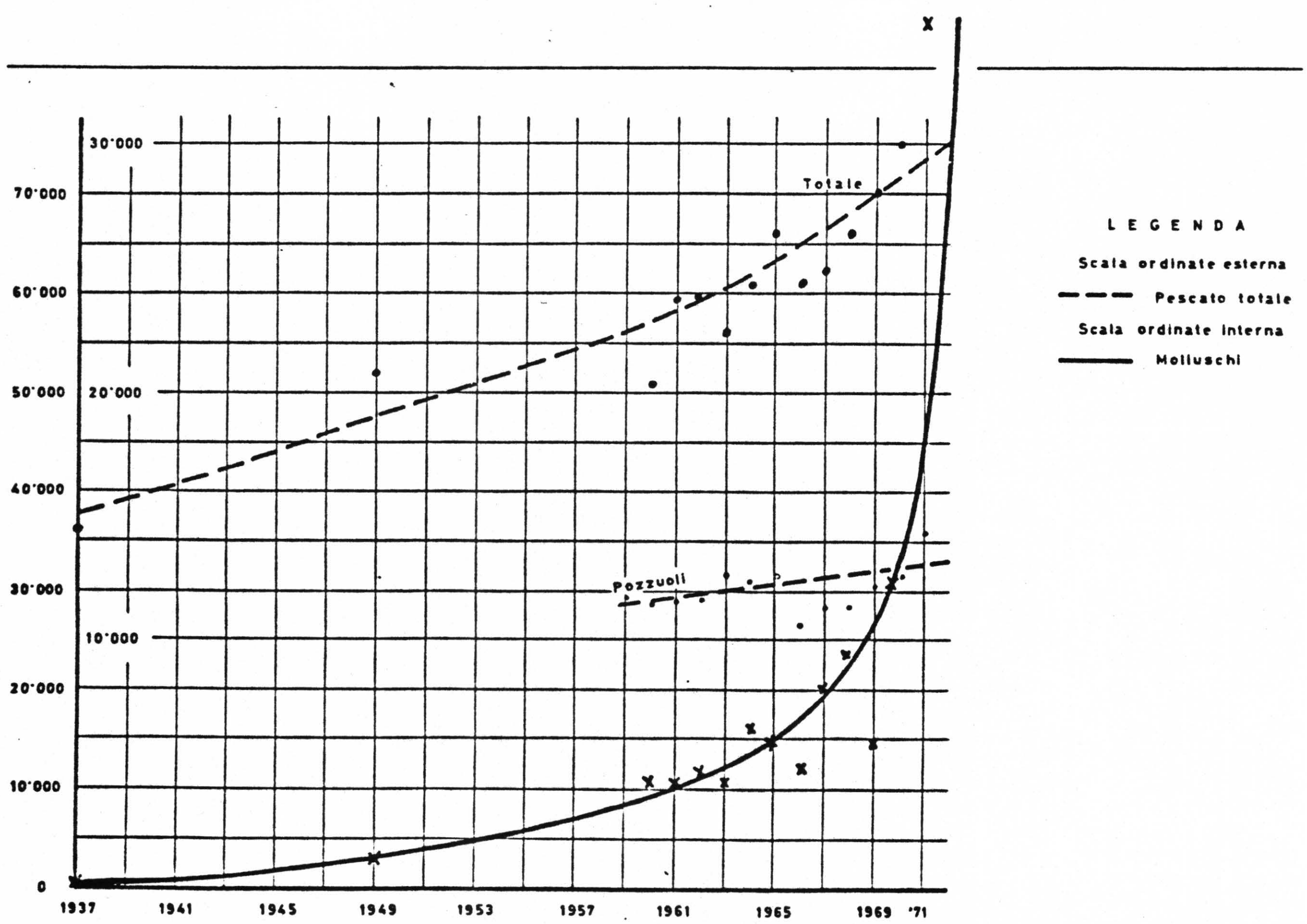


Pesca - Andamento del naviglio peschereccio nell'ambito della provincia: tonnellaggio

Figure 34. Fishboat tonnage for the Gulf of Naples (Eurostaff Report, vol. II, 1973).



Pesca- Andamento raccolta crostacei per la zona Pozzuoli-
- Procida (tonnellate)



Pesca- Andamento del pescato totale e dei molluschi eduli nell ambito provinciale(quintali)

Figure 35. Fish catch statistics for the Gulf of Naples (Eurostaff Report, vol. II, 1973).

would be approximately 7200 Kg per Km^2. Even though much of the field yield is shellfish, the productivity of the area is considerable.

XI. Discussion of Waste Treatment Alternatives

It became obvious during the course of literature review that the problem of street runoff, sewage and industrial waste disposal has been accumulating throughout the years. As the city grew, it continually compounded the problem of waste disposal. The older sewage lines were covered over by the growing city and new lines were added. The flow of sewage followed the contours of the terrain and the easy way to cope with the engineering was to provide a multitude of small outfalls directly into the waters edge of the surrounding coast. At first the area was able to accept the input with little ecological problems. However as our technology advanced wastes accumulated to the approximately 757 liters of water and 3 Kilo of solid waste per person in each day. As the industrial growth increased, it was simple to provide waste disposal through the sewage lines. Also street runoff for much of the area also was routed to the sewage lines.

As a result considerable expense and facility development will be needed to provide treatment. First, there is no convenient place to construct major sewage plants within the city. Second, the irregular terrain would either require multiple treatment plants or extensive pumping facilities to route the sewage through large collecting plants. Third, space for industrial waste treatment at the plants is quite limited. In all instances the cost would be very great.

Industrial waste control would reduce the required sewage capacity. However this action would involve recycling of industrial effluents and in most cases require oxidation ponds because of the nature of the industry. Such action would take large amounts of space for the ponds and very delicate control to eliminate air pollution problems.

As a visitor, it became quite apparent that the region could not afford or did not have the time to alleviate all the above problems within present economic constraints. The excessive cost would prohibit a quick solution to the problem.

Therefore as the Eurostaff Report had already accomplished an excellent job identifying the problems, it seemed obvious that some alternate approach than building secondary sewage and industrial waste plants would be required for immediate action.

One alternative was to see if the Bay of Naples could absorb, without ecological damage, the contents of multiple major sewage outfalls if they could be relocated into deeper water as has been advocated by several Italian scientists. It would be within reason to collect several of the existing outfalls into single offshore outfalls thus eliminating the problem of merging sewage pipes in the city.

The question then would be whether the Bay of Naples could absorb the sewage combined wastes of the area. While there is not a large amount of hydrographic information available for the bay, enough information was available to make a preliminary judgement and to show the need for more information.

The fish catch for both the Mediterranean and the Naples area (Figs. 33-35) indicates a continual increase and no major decrease that could suggest adverse effects of pollution on productivity, even though public health problems are apparent. In contrast, it is possible that the increase in nutrients from the sewage of the area may contribute to the increase in fish, as historically the Mediterranean has been notably poor in nutrients.

The current data available for the bay suggest that considerable circulation takes place with associated replenishment from the surrounding bodies of water. The upwelling that occurs from the circulation and deep troughs of the center of the bay is shown by the rise in salinity near the far end of the channels (Fig. 12). This causes the somewhat circular gyres of the water found in the bay (Figs. 9 and 10). The water movement and circulation data are supported by the absence offshore of high numbers of nutrients and coliforms and the dilution seen in coastal sewage zones (Figs. 24-27 and Table 10). The extensive water exchange is also indicated by the low values of nitrogen and phosphorous in the central body of the waters of the Gulf.

The pollution problem of the Naples Harbor arising from the 6 sewage outfalls may also be approached by the open outfall method. The harbor would quickly be self-cleaning when the pollutant effluents are removed. However while this would be true for the sewage it would not control the hydrocarbons polluting from the oil docks. It is possible to increase the flushing and circulation of the harbor by constructing a circulation conduit through a portion of the existing breakwater at an inner location on the Molo San Vicenzo. This action, coupled with strict laws to prohibit bilge pumping, waste disposal over the side of ships or docks, the maintenance of clean dock areas and strict maintenance of the oil docks would be of immediate benefit to the area.

The problem of street runoff will be partially taken care of by the ocean outfalls. The architecture of the city, with so few green areas, would prohibit the expansion of parks or roadside green areas and relieve the use of streets and sidewalks by the animals. Street runoff may be best approached as a social problem that could be best confronted by a citizens action group to devise better ways of cleaning up the streets.

One approach to determine the capability of the Gulf of Naples to absorb the sewage effluent is to construct mathematically a mass balance of the pollutants. This generally requires considerable information and data about the system. However preliminary data are available that will allow a partial demonstration of a mass balance for certain materials from the sewage as they relate to the Gulf system.

Paoletti (1975) indicated that approximately 2.2 million people lived in the drainage area of the Gulf of Naples. If these 2.2 million people produced 0.55 M^3 of sewage each day, including runoff and industrial effluent (this is an estimate used in the U.S.), 1.25 million cubic meters of sewage would be produced per day. The average content of the sewage according to an abstract of data from the Eurostaff Report is; Nitrogen 20 ppm, Phosphorous 10 ppm. These figures yield the value of 25 tons of nitrogen and 12.5 tons of phosphorous entering the Gulf of Naples each day.

The volume of the bay has been estimated to be 2×10^{11} cubic meters. The average values of nitrogen and phosphorous as provided by the 1976 study of the hydrology of the Gulf by the Zoological Station is 0.15 ugA/L nitrogen and 0.08 ugA/L phosphorous, this is equivalent to a standing amount for the Gulf of 403 tons of nitrogen and 476 tons of phosphorous.

While there are only a few data on the currents in the Gulf of Naples, they do indicate a rather continuous and relatively rapid water movement. Figure 10 (De Maio and Moretti 1973), recent data by the Moretti Figure 9 and data from the Eurostaff Report show water movements. The value of 51 cm/sec is approximately 1.6 km per hour. The data by DeMaio and Moretti indicate that the water may pass through the Gulf in one to two days, with upwelling and considerable mixing taking place.

These data also suggest that the amounts of nitrogen and phosphorous entering from the sewage may be accepted by the waters if properly distributed and thus would produce little or no ecological effect. This latter is supported by the data in various reports cited in this paper, which indicate that the shoreline contamination from the various sewage outfalls disappears only a short distance from the outfall. Data from the Zoological Station on nutrients in the Gulf are quite low which suggests that there is little effect from the shoreline pollution.

A balance of nutrients may be shown for the Gulf of Naples as follows:

	Loss (in Tons) Per Year N	P	Gain N	P
Total fish and shellfish catch est. 1975 10,000 Tons	300	20		
Sewage Contribution			9125	4563
Ambient theoretically remaining in system			8825	4543
Ambient reported in hydrographic data			403	480
Lost from the system by currents or precipitation or sedimentation			8422	4063

Nitrogen and phosphorous are continually being removed from the system by the fish catch. The ambient N and P calculated from the available hydrographic data, indicate a much lower standing amount than indicated by the sewage input. This excess N and P must be removed by the currents passing through the Gulf or from chemical precipitation or sedimentation. No data were available for N or P contents of the sediments. However the data for currents in the Gulf support a conclusion that much of the sewage N and P are removed from the system to the Mediterranean Sea.

It must be understood that the above values are only preliminary, taken from a very inadequate data base, and should be used only to demonstrate a method for sewage impact measurement. It does, however, suggest that the Gulf of Naples can absorb the sewage without ecological impact.

Coliforms can also be treated the same way. Approximately 2.2×10^{13} coliforms enter the Gulf each day from sewage. There are 2×10^{17} ml of water in the Gulf and therefore the coliforms undergo mixing to a non-public health status. It is known (Paoletti, 1970), that the survival of coliforms in sea water is between two weeks and one month. This suggests that the dilution, natural death and the water exchange rate in the Gulf would reduce any public health problem if the sewage were properly distributed.

For the purposes of discussion we have assumed a well mixed Gulf. One must also realize that the circulation in the waters may decrease or change directions and thus allow higher concentrations to occur. However, the differences between materials introduced and their concentration, assuming a well mixed system, are large and thus allow a concentration effect to build up without producing an environmental effect.

During some conversations, it was brought out that there is a thermocline in the Gulf during certain periods of the year. If sewage were disbursed below the thermocline it may become entrapped at the interface and thus be concentrated. However visual observations of ocean outfalls in the U.S. indicate that at single source outfalls the fresh water will rise to the surface and that the amount of material released at any one point can be regulated to avoid either the large surface plume of the rising fresh water or entrapment in a thermocline.

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